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ABSTRACT

This curriculum guide contains five units for a course in solar energy applications for vocational agriculture. Each unit is organized in a format containing some or all of the following materials: unit objective, specific objectives, suggested instructor and student activities, list of instructional materials, assignment sheets, answers to assignment sheets, job sheets, unit test, and answers to test. Topics covered include (1) energy conservation in the home and on the farm, (2) alternative energy sources, (3) solar energy as an energy source and characteristics of solar radiation, 4) storage and distribution of solar energy, and (5) solar collectors. (YLB)

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SOLAR ENERGY APPLICATIONS FOR AGRICULTURE

A Curriculum Guide

Prepared by
Department of Agricultural Education
Institute of Agriculture and Natural Resources
The University of Nebraska-Lincoln
Lincoln, Nebraska
Dr. O.S. Gilbertson, Director
Allan R. Vyhnalek, Project Investigator
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Materials were reviewed and modified and new materials were added, by:

AGRICULTURAL ENGINEERING STAFF, UNIVERSITY OF NEBRASKA-LINCOLN

Dr. Gerald Bodeman
Dr. Jack Schinstock

SMALL FARM ENERGY PROJECT, HARTINGTON, NEBRASKA

Rob Aiken
Dennis Demmel
Ron Krupicka

NEBRASKA ENERGY OFFICE

Pat Idler
Gary Lay

AGRICULTURAL TEACHER EDUCATION STAFF,
UNIVERSITY OF NEBRASKA-LINCOLN

Dr. Allen G. Blezek
Allan Vyhnalek
Michael McDowell
William Umbaugh
James Wilson

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O.S. Gilbertson, Director
Solar Energy Application
for Agriculture

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Unit III Introduction To Solar Energy

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Unit V Solar Collectors

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to describe the energy consumption of persons in the United States and list renewable and nonrenewable energy sources. The student should know ways to conserve energy in the home, on the farmstead and when operating agricultural equipment. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with energy conservation to the correct definition.
2. Complete the chart of energy consumption in the United States.
3. Distinguish renewable energy sources from nonrenewable sources.
4. Distinguish between the advantages and disadvantages of energy conservation.
5. Describe four energy conservation measures for the home.
6. Identify conservation measures for the farmstead and buildings.
7. Describe four energy conservation measures for field operations.
8. Demonstrate the ability to calculate savings from using reduced wattage in light bulbs.
9. Demonstrate the ability to calculate savings of eliminating field operations.
10. Demonstrate the ability to complete an energy checklist.

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

A. Provide students with objective sheet.

B. Provide students with information sheet.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheets.

F. Discuss and fill out assignment sheets.

G. Advise students about filling out checklist.

H. Give test.

II. Student:

A. Read objective sheet.

B. Study information sheet and take notes.

C. Complete Assignment sheet.

D. Complete Job sheet.

E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objectives

B. Information sheet

C. Transparency Masters

1. TM 1—Energy Consumption in U.S.

2. TM 2—Where Heat Loss Outside Homes Occurs—Part 1

3. TM 3—Where Heat Loss Outside Homes Occurs—Part 2

4. TM 4—Areas Where Heat is Lost in the Home

5. TM 5—Types of Insulation

6. TM 6—Types of Caulking Compounds

7. TM 7—Steps of Caulking Process

8. TM 8—Types of Weather Stripping

D. Assignment Sheet
#1 — Savings From Reduced Wattage in Light Bulbs

#2 — Conservation by Eliminating Field Operations

#3 — Completing the Farm Energy Management Checklist

E. Answers to Assignment sheet

F. Job sheet

G. Test

H. Answers to test

II. References

A. "Energy Conservation—In the Home—On the Farm", prepared by Department of Agricultural Education, in cooperation with Ag Ed Section, Bureau of Voc. Ed., Dept. of Ed., Harrisburg, Pennsylvania, The Pennsylvania State University and Pennsylvania Farm Electrification Council.

B. "Farm Energy Conservation Checklist", Small Farm Energy project, Center for Rural Affairs, P.O. Box 736, Hartington, NE 68739

C. "Nebraska Farm Custom Rates, Part I and II", Nebguide G75-207, G75-249, Cooperative Extension Service, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

D. "Energy and U.S. Agriculture: A Statewide Energy Management and Conservation Program for Production Agriculture in Nebraska", by Department of Agricultural Engineering, University of Nebraska, August 1977.

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Energy—ability to do work

B. Fossil Fuels—Fuels formed from plant and animal material which was subjected to a great deal of pressure for a long period of time. (millions of years) Examples: oil, coal, natural gas

C. Energy conservation—Wise and conservative use of energy resources so they will last longer.

D. B.T.U. (British Thermal Unit)—Heat required to raise the temperature of one pound of water one degree Fahrenheit.

E. Caulk—Waterproof material used to seal cracks and help prevent buildings from losing heat or allowing cold air infiltration. (Note: opposite is true in the summer)

F. Insulation—Material that will not allow electricity, heat, or sound to pass through it.

G. R-Value—Resistance of insulation to heat passing through it determines the R-value. A high R-value has more resistance to heat, coolness and sound.

H. Ventilation—Provide an opening for the escape of foul or unwanted air and to allow fresh air to enter.

I. Solar Energy—Energy received from the sun.

II. Energy Consumption in the United States

A. Personal energy use accounts for 37% of the total energy use (Transparency 1)

1. 42% transportation
2. 40% heating and air conditioning
3. 6% hot water
4. 4% cooking
5. 4% refrigeration
6. 1% lighting
7. 3% miscellaneous

B. Business and government account for 63% of total energy use

1. 41% industrial
2. 14% commercial
3. 8% transportation

INFORMATION SHEET

C. The United States accounts for 6% of the world's population, but accounts for 1/3 of the world's energy consumption.

III. Renewable and nonrenewable energy sources

A. Renewable energy sources

1. Solar energy
2. Alcohol
3. Wind
4. Geothermal
5. Wood

B. Nonrenewable energy sources (fossil fuels)

1. Coal
2. Natural gas
3. Oil (gasoline and diesel fuel)
4. Nuclear (Note: although nuclear energy is not a fossil source of energy, it is considered nonrenewable because there is only so much uranium in the world.)

IV. Advantages and disadvantages of energy conservation

A. Advantages of energy conservation

1. Saving fossil fuels for future use
2. Minimize air, water and land pollution
3. Savings on fuel and electric bills

B. Disadvantages of energy conservation

1. Personal sacrifice
2. Lower standard of living
   a. cooler in winter—warmer in summer
   b. less use of personal car

INFORMATION SHEET

V. Energy conservation measures for the home

A. Where energy losses occur in the home

1. Outside energy losses (Transparency 2, 3)

a. where different materials of house join

b. water faucets

c. windows

d. vents

e. doors

B. Where energy losses occur inside the home (Transparency 4)

1. a. windows

b. light fixtures

c. pipes

d. doors

C. Types of Insulation (Transparency 5)

1. Flexible

2. Loose fill

3. Rigid board

4. Foamed in place

D. Caulking and weather stripping

1. Sealing cracks with an inexpensive caulking compound or by using weather stripping material can result in as much as a 15 percent savings on the fuel bill

2. Caulk is available in bulk, tubes and ropes (Transparency 6)

3. Steps in caulking process (Transparency 7)

a. scrape old material out of crack

b. clean the surface

c. caulk cleaned surface

4. Types of weather stripping (Transparency 8)

a. foam rubber

INFORMATION SHEET

b. vinyl

c. metal strip

E. Window shades

1. Open during winter days and summer nights

2. Closed during winter nights and summer days

F. Heat pump

G. Supplemental Heat

1. Fireplaces—make sure the damper is closed after use

2. Wood Stoves

H. Water Savings (less energy used due to less heating of water)

1. Setting water heater thermostat to 110°-120°F

2. Wash only full loads of laundry

3. Use dishwasher only when full

4. Take showers rather than baths

I. Cooling and refrigeration

1. Match cooling unit to fit job requirement

2. Keep refrigerators away from heat sources

3. Maintain refrigerator seals and gaskets.

4. Use chest freezers (more efficient)

5. Be sure the refrigerator/freezer is well insulated

6. Keep freezers full

7. Defrost regularly

J. Cooking

1. Keep oven seals in good repair

2. Use proper burner size for pan size

3. Use self-cleaning feature on oven sparingly

K. Lighting

1. Energy saving bulbs

INFORMATION SHEET

2. Flourescent bulbs
3. Keep bulbs and reflectors clean
4. Turn lights off when not in use
5. Reduce wattage when possible

VI. Energy conservation measures for the Farmstead

A. Space heating buildings

1. Insulate where feasible
2. Reduce drafts
3. Consider exposure of buildings
4. Consolidate animals
5. Consider economics of each type of heat that could be used
6. Determine minimum heating requirements

B. Ventilation

1. Eliminate mechanical ventilation in facilities by using cold, partially open, and naturally ventilated structures
2. Consider a convertible system-closed, warm and mechanically ventilated during cold months-open and naturally ventilated during warm months
3. Reduce ventilation rate to minimum levels and increase air circulation within the structure during hot months to compensate
4. Turn fans off when ventilation is not required (example: when cows are out to pasture for several hours each day)
5. Select fans with high cfm/per watt rating
6. Clean fans and shutters frequently—lubricate fans—keep belts tight—check thermostats
7. Do not over ventilate during cold weather months and waste supplemental heat
8. Use temperature controlled, variable speed fans, two-speed fans, or motor operated fan shutters which provide continuous, but greatly reduced air flow during severe winter weather, will reduce fuel consumption in heated buildings

C. Lighting

1. Use lower wattage bulbs
2. Use lower wattage reflector bulbs

3. Replace regular fluorescent bulbs with watt misers
4. Turn lights off when not in use
5. Use task lighting and reduce whole area or room lighting
6. Use high-intensity discharge bulbs
   a. Mercury vapor
   b. High pressure sodium
7. Use light dimmers where total wattage of bulbs gives more light than needed

D. Water Heating

1. Preheat incoming water with heat exchanger
2. Drain heater and remove lime deposits on a periodic basis
3. Repair all leaking faucets
4. Insulate around outside including top and bottom of water heater
5. Insulate hot water lines which run through unheated areas
6. Keep temperature setting at low level
7. Use hot water prudently

E. Refrigeration

1. Use heat exchanger coupled with a refrigerant compressor
2. Keep compressor condensers and fans clean

F. Feed handling and processing equipment

1. Size motor to the job
2. Correlate electric motor with capacity
3. Operate at capacity as much as possible
4. Keep motors and equipment lubricated and clean
5. Install electric wiring for motors which is heavy enough gauge to minimize voltage drops
6. Maintain proper V-belt tension

INFORMATION SHEET

VII. Energy conservation measures for field operations

A. Soil Fertility

1. Use high analysis fertilizers, for more units of plant food per ton
2. Use ammoniated starters to enhance early germination and reduce replanting risk
3. Plow down all P and K when planting clear-seeded alfalfa for 3-year stands. Eliminates annual top dressing
4. Handle and store manure in semi-dry form. Spread less frequently, plow down promptly, handle less weight. Nutrients, labor, energy are saved
5. Use nitrogen stabilizers
6. Soil test to determine exact needs

B. Tillage

1. Reduce implement penetration depth
2. Combine field operations when possible
3. Reduce tillage operations
4. Use no-till or zero till
5. Match implement to power
6. Optimize field speed gear up, throttle down when possible
7. Maintain regular engine service, including new filters and tune-ups
8. Reduce idle time
9. Use proper wheel ballasting
10. Use efficient row width
11. Use proper weed control methods
12. Merge small fields into larger more efficient fields
13. Plan and schedule trips

C. Irrigation

1. Develop runoff recovery
2. Use sprinkler rather than furrow irrigation
3. Try trickle rather than furrow irrigation
4. Irrigate under cloudy conditions or at night
5. Maintain and tune the power unit engine

INFORMATION SHEET

6. Operate electric-powered units during low demand periods
7. Check pumping plant efficiency

   (NOTE: efficiency needs not be checked more than once every three years)

D. Harvest

1. Size machine to the job
2. Keep machinery properly lubricated and adjusted
3. Optimize field speed
4. Keep all blades and knives sharp
5. Consider gravity flow equipment
6. Use efficient length or width of cut when harvesting or chopping
7. Use proper weed control

E. Transporting Crops

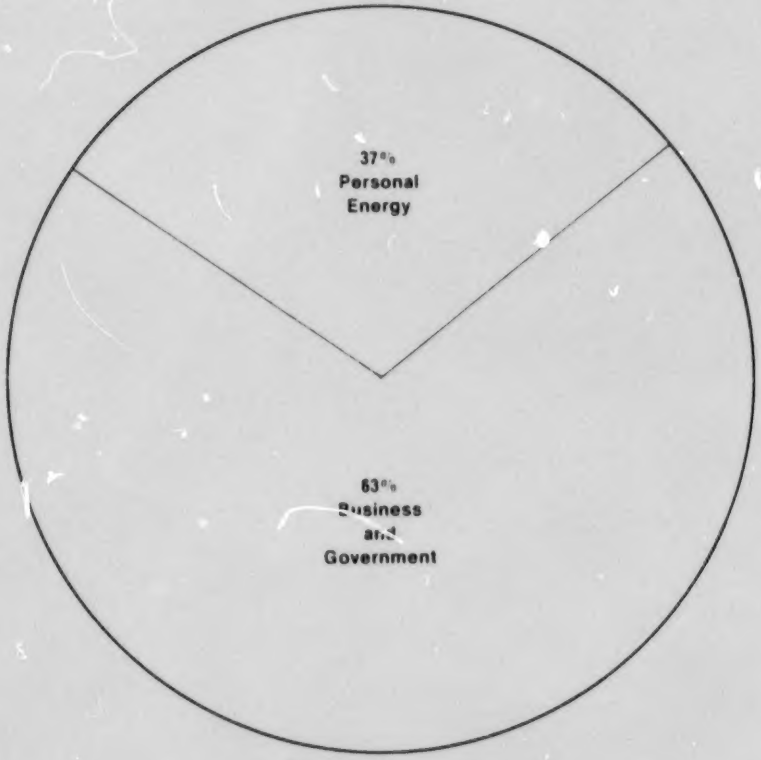
1. Size equipment to the job
2. Use proper wheel ballasting
3. Maintain regular engine service, including new filters and tune-ups
4. Reduce idle time
5. Plan and schedule trips
6. Consider gravity flow equipment

F. Drying and storing crops

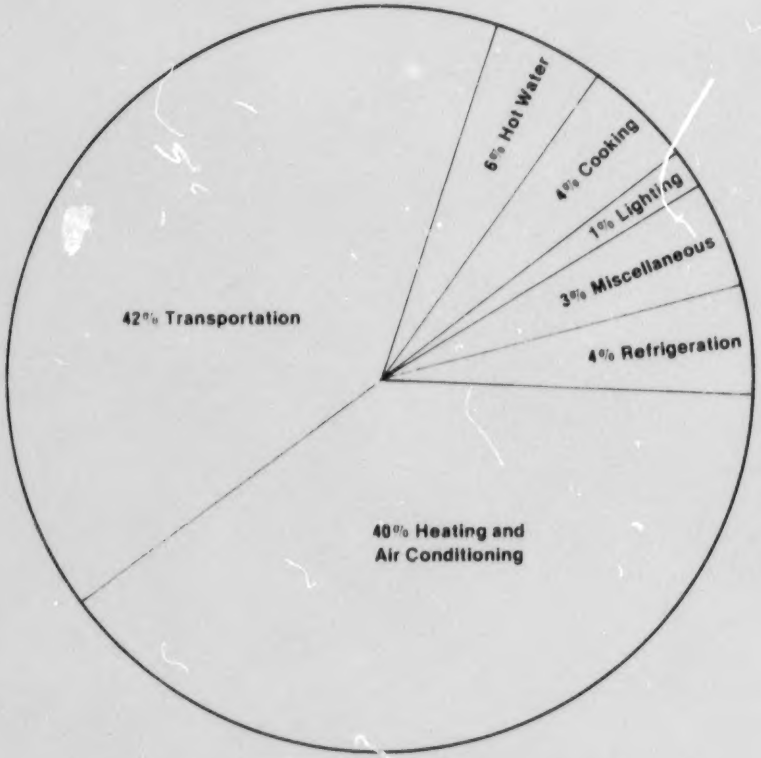
1. Partially dry with heated air to reduce initial moisture content, use natural air to finish
2. Use early maturing varieties
3. Field dry to the fullest practical extent
4. Buy a good moisture tester and use it
5. Do not over dry
6. Clean grain to remove fines and reduce power needed to move air through grain
7. Use as little grain depth as possible and level the top when drying
8. Keep dryer serviced properly
9. Use natural drying whenever possible especially for hay

ENERGY CONSUMPTION IN U.S.

TOTAL ENERGY CONSUMPTION IN U.S.



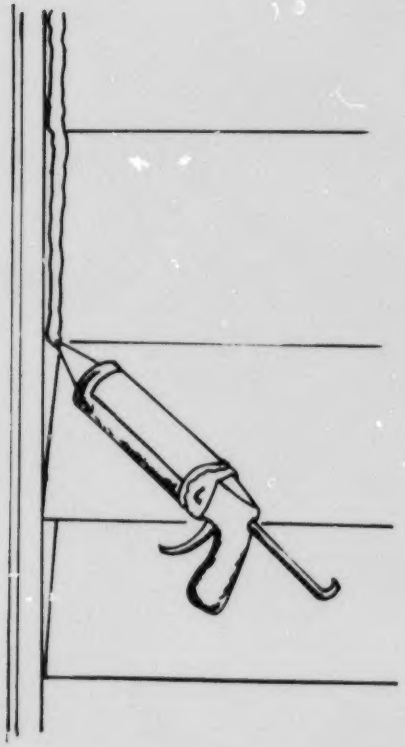
PERSONAL ENERGY CONSUMPTION



TM1

SE-13

Where Heat Loss Outside The Home Occurs (Part 1)



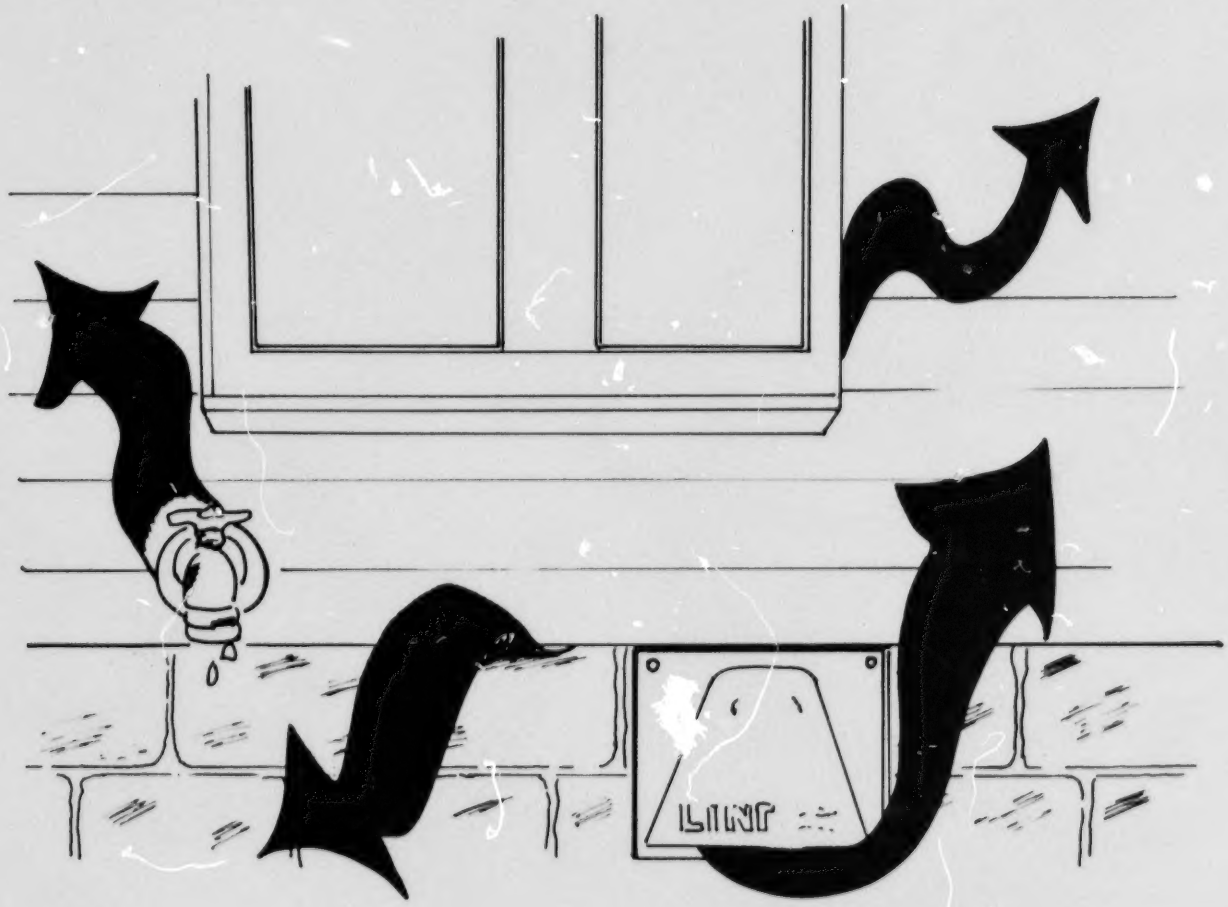
Caulk all cracks to reduce heat loss.

Heat escapes wherever two different materials or parts of house join.

TM2

SE-15

Where Heat Loss Outside Homes Occurs (Part 2)

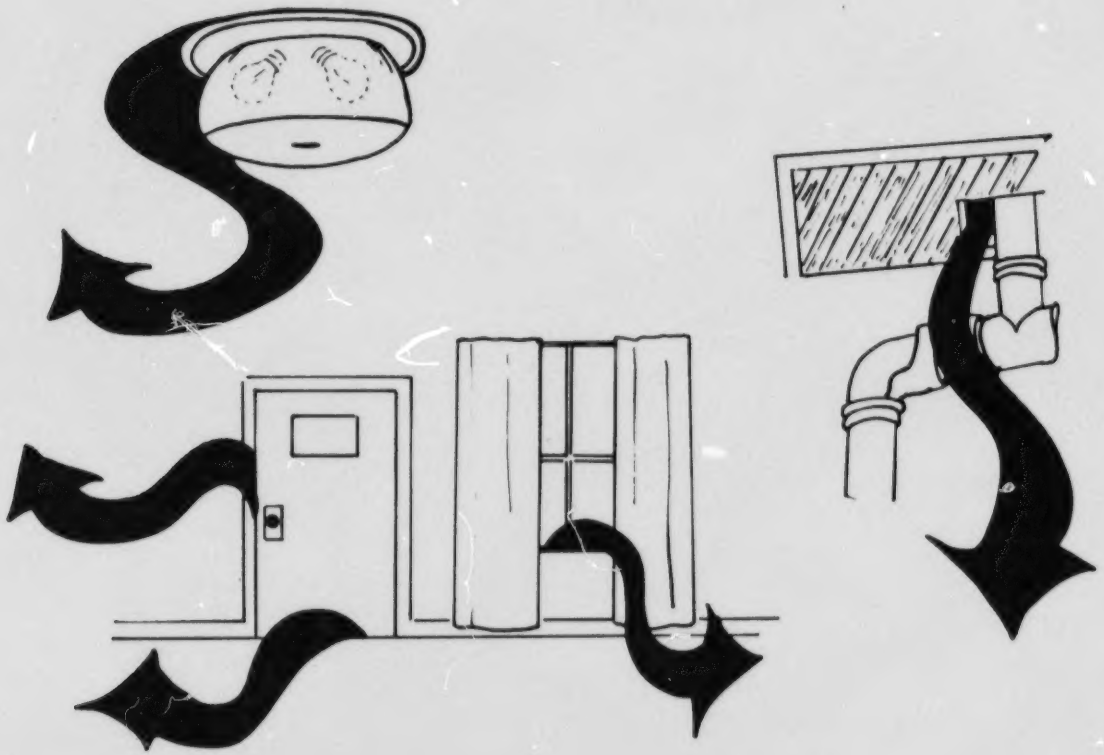


Common areas of heat loss outside the home

TM3

SE-17

Areas Where Heat is Lost in the Home

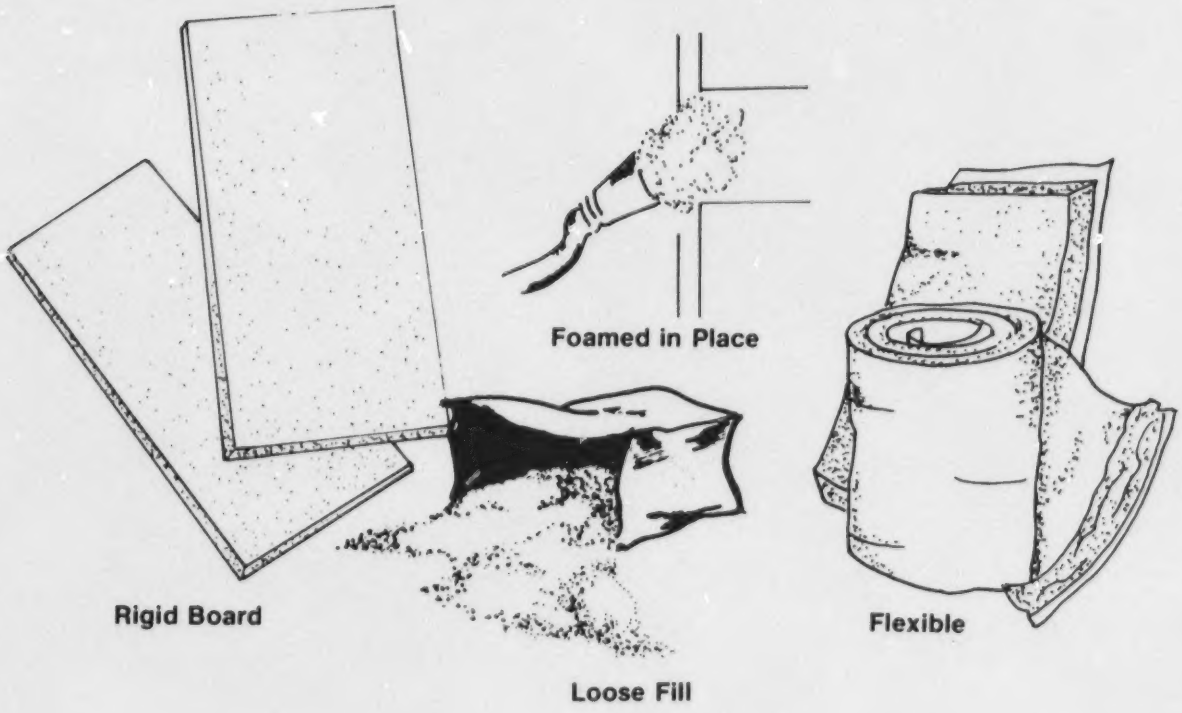


Common areas where heat loss occurs inside the home

TM4

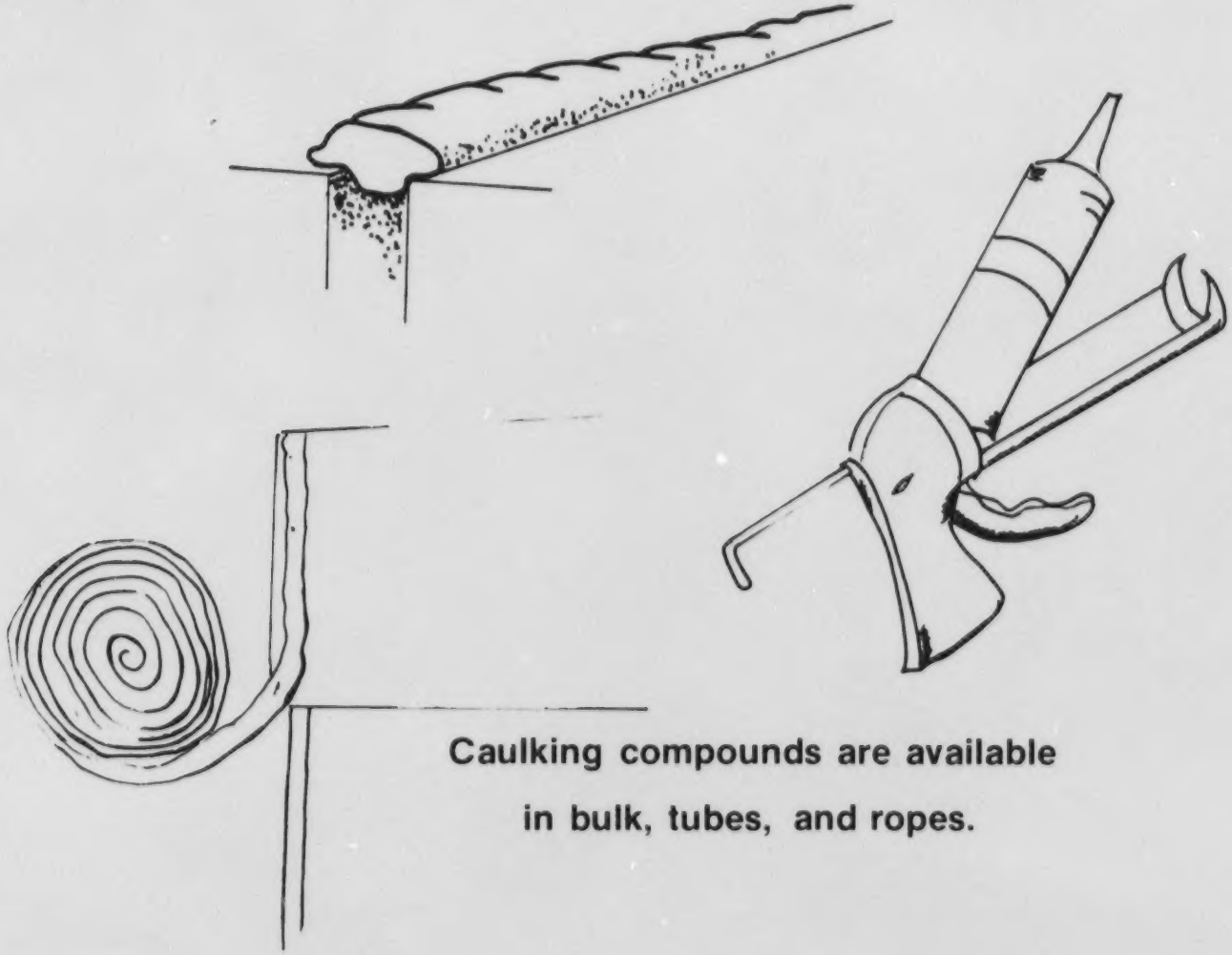
SE-19

Types of Insulation



TM5

Types of Caulking Compounds

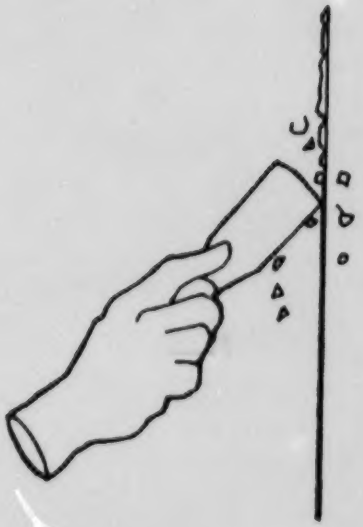


Caulking compounds are available in bulk, tubes, and ropes.

TM6

SE-23

Steps in caulking process



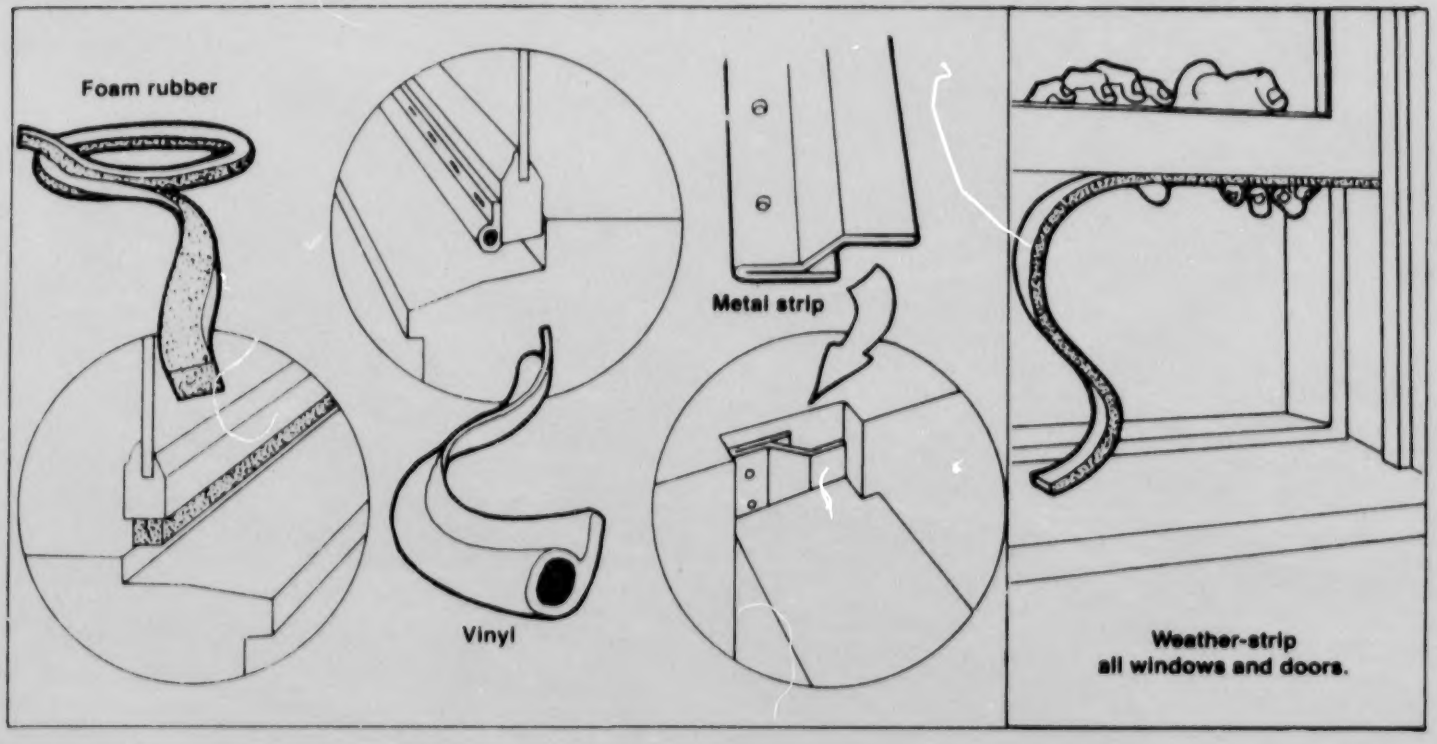
Scrape

Clean

Caulk

TM7

Types of Weather Stripping



ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

ASSIGNMENT SHEET NO. 1: SAVINGS FROM REDUCED WATTAGE IN LIGHTBULBS

With the given yearly cost chart below calculate savings of reducing wattage of lightbulbs.

Yearly Costs of Operating Lightbulbs 8 Hours Daily

Lightbulb Watts	Dollars/KWH				
	.03	.04	.05	.06	.07
25	2.20	2.90	3.65	4.35	5.10
40	3.50	4.65	5.80	6.95	8.10
75	6.55	8.75	10.90	13.10	15.25
100	8.75	11.65	14.55	17.45	20.35
150	13.10	17.50	21.80	26.15	30.50

Example: One 75 watt bulb replacing a 100 watt bulb saves $3.65 yearly at 5¢ per KWH or 14.55 - 10.90 = 3.65.

1. If electricity costs $.03 per KWH and you were able to replace a 100 watt bulb with a 40 watt bulb, assuming the bulbs were burned 8 hours a day, what are your yearly savings?

2. Six 150 watt bulbs were replaced by three 100 watt bulbs and three 75 watt bulbs. If these bulbs were used 8 hours per day, what are the yearly savings if electricity costs $.06 per KWH?

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

ASSIGNMENT SHEET NO. 2: CONSERVATION BY ELIMINATING FIELD OPERATIONS

Farmer A and Farmer B prepare their ground for corn two different ways. Given the information below calculate the following:

Farmer A does the following: shreds stalks, plows, disks, fertilizes (Anhydrous Ammonia), springtooth, harrow, plants

Farmer B does the following: disk, fertilizers (Anhydrous Ammonia), disk, plants

Cost of the operations per acre:

Plow	$6.00	A.A.	$3.00
Shred Stalks	$3.25	Harrow	$2.00
Disk	$3.00	Plant	$4.50
Springtooth	$2.50		

1. Which farmer has the least expensive method? A or B
2. What are the savings per acre? _____
3. What would be the savings for 200 acres? _____

Information

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

ASSIGNMENT SHEET NO. 3: COMPLETING THE FARM ENERGY MANAGEMENT CHECKLIST

Place a check in the "completed" column if this is an energy saving measure you have or are countinuing to do on your farm. Place a check in the "will investigate" column if this is an energy saving measure you would like to consider or investigate for your farm.

	Completed	Will Investigate
Farm Tractors		
Select the proper tractor size to fit the operation.	( )	( )
Follow regular maintenance and tune-up procedures.	( )	( )
Limit engine idling.	( )	( )
Use proper ballast		
—to reduce slippage.	( )	( )
—remove when not needed.	( )	( )
Utilize proper tire pressure.	( )	( )
Clean air and fuel filters.	( )	( )
Adjust carburetors.	( )	( )
With light loads, gear up, throttle down.	( )	( )
Use timers for engine block heaters.	( )	( )
Avoid hydrostatic drives.	( )	( )
Keep fuel use records.	( )	( )
Irrigation		
Use sprinkler rather than furrow irrigation.	( )	( )
Irrigate when cloudy, at night, or lower temperatures, (when possible).	( )	( )
Maintain and tune power unit.	( )	( )

	Completed	Will Investigate
Farm Trucks and Autos		
Carry loads to vehicle capacity, do not overload.	( )	( )
Plan and schedule trips.	( )	( )
Follow regular maintenance programs.	( )	( )
Inflate all tires properly.	( )	( )
Avoid excessive motor idling.	( )	( )
Use radial tires.	( )	( )
Utilize electronic ignitions.	( )	( )
Avoid air conditioning and other power equipment.	( )	( )
Eliminate unnecessary trips.	( )	( )
Water Heating		
Keep temperature setting at low level.	( )	( )
Repair all water leaks.	( )	( )
Insulate water heaters.	( )	( )
Insulate water lines.	( )	( )
Preheat incoming water with heat exchanger.	( )	( )
Drain water heater and remove lime deposits on a periodic basis.	( )	( )
Use automatic waters instead of continuous flow.	( )	( )
Locate water heater close to its use.	( )	( )
Farm Yard		
Plant shade trees and/or shelter belts.	( )	( )
Eliminate or minimize yard lights.	( )	( )
Use mercury vapor or high pressure sodium lights.	( )	( )
Switch to lower wattage bulbs.	( )	( )
Mulch gardens to save water and weeds.	( )	( )
Use animals to mow weeds and grass.	( )	( )

	Completed	Will Investigate
Buildings		
Have good vapor barriers for insulation.	( )	( )
Ventilation.		
—Turn fans off when ventilation is not required.	( )	( )
—Clean fans and shutters frequently.	( )	( )
—Avoid over ventilation.	( )	( )
Use insulation where feasible.	( )	( )
Switch to lower wattage light bulbs.	( )	( )
Use storm windows where feasible.	( )	( )
Grain Drying		
Harvest corn, ear to crib (where feasible).	( )	( )
Field dry to lower moisture.	( )	( )
Use low temperature natural aeration (when possible).	( )	( )
Do not overdry.	( )	( )
Cooling will also dry.		
Partial dry with heat, then aeration.	( )	( )
Clean grain to increase air movement.	( )	( )
Keep dryer and aeration equipment properly maintained.	( )	( )
Preserve grain with an organic acid.	( )	( )
Fertilizers		
Use nitrification inhibitors.	( )	( )
Alternate fertilizers, such as manure, compost, crop rotation with legumes, interseeding legumes.	( )	( )
Place fertilizer in row.	( )	( )
Maximize net gain, not yield.	( )	( )
Test soil.	( )	( )

	Completed	Will Investigate
Tillage Equipment		
Keep all implements lubricated and properly adjusted.	( )	( )
Keep all implements sharpened.	( )	( )
Practice minimum tillage where practical.	( )	( )
Omit field operations where good management permits.	( )	( )
Do not plow deep unless there is a hard pan.	( )	( )
Have a good soil and water conservation plan.	( )	( )
Use contour strip cropping (where feasible).	( )	( )
Combine some field operations into one.	( )	( )
Match equipment size to tractor size.	( )	( )
Use windbreaks to reduce soil erosion.	( )	( )
Use terraces to conserve nutrients and water.	( )	( )
Keep belts at proper tension.	( )	( )

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment sheet No. 1

1. 100 watt bulb costs $8.75 to run for 1 year
   40 watt bulb costs - 3.50 to run for 1 year
   5.25
   There would be a yearly savings of $5.25.

2. Cost of operating one 150 watt bulb is $26.15
   Cost of operating six is x 6
   156.90

   Cost of operating 3 - 100 watt bulbs is $17.45
   x 3
   52.35

   Cost of operating 3 - 75 watt bulbs is $13.10
   x 3
   39.30

   Add 52.35 + 39.30 = 91.65 — $91.65 cost of reduced wattage bulbs for one year

   156.90-91.65 = 65.25 — $65.25 Savings per year

Assignment Sheet No. 2

Farmer A's costs to prepare 1 acre =
- 3.25 Shred Stalks
- 6.00 Plow
- 3.00 Disk
- 3.00 A.A.
- 2.50 Springtooth
- 2.00 Harrow
- + 4.50 Plant

$ 24.25 cost to prepare 1 acre

Farmer A's cost for 200 acres = 24.25 x 200 = $4850.00

Farmer B's cost to prepare 1 acre =
- 3.00 Disk
- 3.00 A.A.
- 3.00 Disk
- + 4.50 Plant

$13.50

13.50 x 200 = $2600.00

Farmer B's cost for 200 acres = $2600.00

Farmer B is saving money

His Savings for 1 acre: 24.25 - 13.50 = 10.75

His Savings for 200 acres: 4850.00 - 2600.00 = $2150.00

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

TEST

Name _____

1. Match the terms on the right to the correct definitions.

____ a. Provide an opening for the escape of foul or unwanted air and to allow fresh air to enter.

____ b. Ability to do work.

____ c. Wise and conservative use of energy resources so they will last longer.

____ d. Heat required to raise the temperature of one pound of water one degree Fahrenheit.

____ e. Fuels formed from plant and animal material which was subjected to a great deal of pressure for a long period of time.

____ f. Energy received from the sun.

____ g. Resistance of insulation to heat passing through it determines the R-value. A high R-value has more resistance to heat, coolness and sound.

____ h. Material that will not allow electricity, heat or sound to pass through it.

____ i. Waterproof material used to seal cracks and help prevent buildings from losing heat or allowing cold air infiltration.

1. Insulation
2. Caulk
3. Energy
4. Fossil Fuels
5. R-value
6. Ventilation
7. Solar energy
8. B.T.U.
9. Energy Conservation

2. Complete the chart of energy consumption in the United States by filling in the blank with the percent of energy consumption that corresponds to each.

Personal energy use	**Business and Government energy use**
____ transportation	____ industrial
40% heating and air conditioning	14% commercial
____ hot water	____ transportation
____ cooking	4% refrigeration
____ lighting	3% miscellaneous

3. Distinguish between the renewable energy sources from the nonrenewable energy sources by placing an R by those energy sources which are renewable and by placing an N by those energy sources that are nonrenewable.

____ a. Nuclear energy
____ b. Alcohol
____ c. Geothermal
____ d. Coal
____ e. Oil
____ f. Solar energy
____ g. Wind
____ h. Natural gas
____ i. Wood

4. Place an A by the advantages of energy conservation and place a D by the disadvantages of energy conservation.

____ a. Savings on fuel and electric bill
____ b. Less use of personal car
____ c. Cooler in winter, warmer in summer
____ d. Helping to keep air, water, and land pollution to a minimum
____ e. Unwilling to make personal sacrifice
____ f. Saving fossil fuel for future use

5. Describe four energy conservation measures for the home.

a.

b.

c.

d.

6. Identify from the list below, energy conservation measures for the farmstead and buildings by placing an X by those energy conservation measures which are for farmsteads and buildings.

Spaceheating buildings

____ a. Leave doors open in winter

____ b. Consider exposure of building

____ c. Reduce drafts

____ d. Don't repair cracks in walls

____ e. Insulate where feasible

____ f. Use most expensive heat available

____ g. Determine minimum heating requirements

Ventilation

____ h. Never lubricate fans or clean shutters

____ i. Eliminate mechanical ventilation in facilities by using cold, partially open, and naturally ventilated structures

____ j. Leave fans on when ventilation is not required

____ k. Reduce ventilation to minimum levels and increase air circulation within the structure during hot months to compensate

____ l. Select fans with high cfm per watt rating

Lighting

____ m. Keep the whole room lighted when working in one area of the room

____ n. Use lower wattage bulbs where possible

____ o. Dimmers do not help reduce energy bill

Water Heating

____ p. Reduce thermostat temperature setting

____ q. Leave leaking faucets leak

____ r. Not necessary to insulate hot water lines

____ s. Preheat incoming water with heat exchanger

____ t. Do not remove lime deposits

Refrigeration

____ u. Keep compressor condensors and fans clean

Feed Handling and Processing Equipment

____ v. Use any size motor for the job

____ w. Operate at capacity as much as possible

____ x. Not necessary to clean and lubricate motors

____ y. Maintain proper V-belt tension

____ z. Correlate electric motor work with rated capacity

7. Describe four energy conservation measures for field operations.

a.

b.

c.

d.

ENERGY CONSERVATION IN THE HOME AND ON THE FARM
UNIT I

ANSWERS TO TEST

1. a. 6
   b. 3
   c. 9
   d. 8
   e. 4
   f. 7
   g. 5
   h. 1
   i. 2

2. 42% transportation
   6% hot water
   4% cooking
   1% lighting
   41% industrial
   8% transportation

3. a. N
   b. R
   c. R
   d. N
   e. N
   f. R
   g. R
   h. N
   i. R

4. a. A
   b. D
   c. D
   d. A
   e. D
   f. A

5. Graded to satisfaction of instructor

6. An X should be placed by the following letters:

b	n
c	p
e	s
g	u
i	w
k	y
l	z

7. Graded to the satisfaction of the instructor

ALTERNATIVE ENERGY SOURCES
UNIT II
UNIT OBJECTIVE

After completion of this unit, the student should be able to list the four alternative energy sources. The student should know how each is used and describe the potential use of these energy sources. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with alternative energy sources to their correct definition.
2. List the four alternative sources of energy.
3. List four reasons why the sun is a useful energy source.
4. Identify true statements concerning photovoltaic energy.
5. Name the five parts of a thermal solar collector.
6. Select the true statements about Gasohol.
7. List seven advantages of using Gashol.
8. List six disadvantages of using Gasohol.
9. List three Historical uses of wind as an energy source.
10. Select from a list the advantages of wind as an energy source.
11. Select from a list the disadvantages of wind as an energy source.
12. List the seven components of a wind generation system.
13. Describe the two steps of methane production.
14. Name the four main features and the nine sub features of a methane plant.

ALTERNATIVE ENERGY SOURCES
UNIT II
SUGGESTED ACTIVITIES

I. Instructor

A. Provide students with objective sheet.

B. Provide students with information sheet.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheets.

F. Give test.

II. Student

A. Read objective sheet.

B. Study information sheet and take notes.

C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objectives

B. Information sheet

C. Transparency Masters

1. TM 1 — Steps of Methane Production

2. TM 2—Typical Features of an on-farm Biogas Plant

D. Test

F. Answers to Test

II. References

A. "Energy Uses in Nebraska Agriculture" Prepared for Nebraska Energy Office, Box 95805, Lincoln, NE 68509

B. "Methane Production Systems For Swine Manure" Missouri Agricultural Experiment Station Journal, Series Number 8052.

C. "Energy From Winds" U.S. Department of Energy, Office of Public Affairs, Washington, D.C. 20585. DOE/OPA-0031R

D. "Windmills and Wind Power" Division of Agricultural Sciences, University of California, leaflet 2386

E. "Gasohol" Prepared for the Nebraska Energy Office, Box 95805, Lincoln, NE 68509

ALTERNATIVE ENERGY SOURCES
UNIT II
INFORMATION SHEET

I. Terms and Definitions

A. Thermal solar collection—heat transmitted by sun's rays. Warms masses of air, water, or other transport medians.

B. Photovoltaic energy—collection of electrical energy from the sun.

C. Biomass Conversion—energy from the sun is stored through the process of photosynthesis in plants, or other organic material. When the organic material is converted to simpler forms, energy is released.

D. Gasohol—a fuel mixture of unleaded gasoline and ethanol.

(NOTE: usually a fuel mixture of 90% unleaded gasoline and 10% ethanol)

II. Alternative Sources of Energy

A. Solar

1. Photovoltaic

2. Thermal

B. Gasohol

C. Wind

D. Methane

III. Usefulness of the sun as an energy source

A. Natural source

B. Clean and safe

C. Inexhaustible energy source

D. Available year-round

IV. Photovoltaic solar cells

A. Sunlight hitting a solar cell

1. Sunlight hits the cell, activating electrons which are collected as electrical energy

B. Cells are made primarily of silicon

C. Cells are 2'' in diameter

D. Individual cells collect one-quarter of a watt of electricity in bright sunlight

E. Cells will provide electricity even on cloudy days or under snow cover

F. As new manufacturing processes are developed, and demand increases, prices will drop

INFORMATION SHEET

V. Thermal solar collection

A. Collection is through the use of a solar collector

1. Collector parts

a. Plyboard backing
b. Absorber surface
c. Glazing sheet
d. Dead air sheet
e. Heating space

VI. Facts about Gasohol

A. In World War I and II, some tanks and planes carried "wood stills" to produce alcohol as a fuel when gasoline supplies were short

B. In Nebraska 45 vehicles were run for almost 3 years for 2 million miles on gasohol. Some of the results were:

1. Gasohol can be burned in any internal combustion engine regardless of age without carburetor modification

2. Gasohol has a octane rating 3 points higher than unleaded gasoline

3. Exhaust emissions from gasohol contain one-third less carbon monoxide and one-tenth as many hydrocarbons as the emissions from unleaded gasoline

4. Gasohol causes no unusual engine wear

5. Gasohol fueled vehicles consumed 5% less fuel than vehicles driven only on unleaded fuel

VII. Advantages of Using Gasohol

A. Emissions

1. Less carbon monoxide

2. Total emissions are somewhat less than for unleaded gasoline

B. By-products

1. Distillers dried grain

a. By product of fermentation

b. Contains 28-30% protein by weight

C. Reduce the importing of crude oil

1. Four billion gallons of grain alcohol converted to Gasohol would result in a 178 million barrels of crude oil savings each year

D. New market for farmers' grains

INFORMATION SHEET

E. The average octane rating is 3 points higher than unleaded gasoline

F. Gasohol fueled vehicles consume 5% less than those running on unleaded gasoline.

G. Sufficient amounts of grain and sugar are available in the United States to produce Gasohol without upsetting the food and feed markets.

H. Gasohol has a higher water tolerance than pure gasoline

I. Better winter starting, fewer vapor-lock problems during summer

J. Gasohol can be burned without carburetor modification

K. Grain used to produce Gasohol need not be the highest quality grain

VIII. Disadvantages of Using Gasohol

A. Ethanol is more costly than available fossil fuels

B. BTU's produced by ethanol is less than that produced by gasoline
(NOTE: ethanol produces 85,000 BTU, gasoline produces 135,000 BTU)

C. Food grains could be used to feed the world's hungry rather than automobiles

D. It would require 2.7 times more energy to produce ethanol, than ethanol can deliver to the engine.

E. The large subsidies required for a gasohol program aren't justified by the small benefits that farmers would receive

F. The high energy requirements of mechanized, high-yield farming makes it impractical to depend on agriculture to provide the energy needs of a technological society

G. Assuming a nation wide gasohol program, there would be a sharp downward pressure on prices of both distillers dry grain and soybeans

H. Collection of 75% of agricultural residue and using it for fuel is impractical

I. For gasohol to be feasible, corn would have to drop from $3 a bushel to $2 a bushel and ethylene climb from 9 cents a pound to 15 cents before they are competitive

IX. Wind energy as a source of energy for centuries

A. Used to power sails (ships)

B. Used to pump water

C. Grind grain into feed and flour

INFORMATION SHEET

X. Advantages of wind as an energy source

- A. Nonpolluting power source
- B. Renewable energy source
- C. Inexpensive source of energy

XI. Disadvantages of wind as an energy source

- A. Windmills are inefficient

  (NOTE: windmills utilize only 10% to 30% of wind's total power)
- B. Windmills and generators do not generate enough power to pay for the investment
- C. Wind is an unreliable energy source

XII. Components of wind generation systems

- A. Propellor (2 to 4 blades)
- B. Generator
- C. Tower
- D. Brake (stop the units for repair)
- E. Control panel
  1. Prevents reverse battery currents
  2. Voltage regulator
- F. Speed control device (prevents damage of high wind)
- G. Batteries (stores energy for calm periods)

XIII. Steps of Methane Production (Transparency 1)

- A. Organic matter broken down by acid formers, creates simple organic acids
- B. Simple organic acids are broken down by methane formers to produce methane (Biomass)

XIV. Features of a methane plant (Transparency 2)

- A. Barn and manure pit
- B. Digestor
  1. Heat exchanger
  2. Gas diffusor
  3. Pressure relief valve

INFORMATION SHEET

4. Solids removal part

5. Gas

C. Service building

1. Boiler

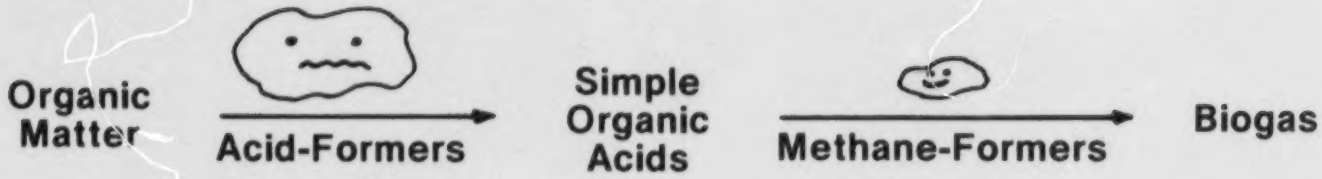
2. Gas Recirculation Compressor

3. Engine

4. Storage over water

D. Lagoon

THE ANAEROBIC DIGESTION PROCESS



Steps of Methane Production

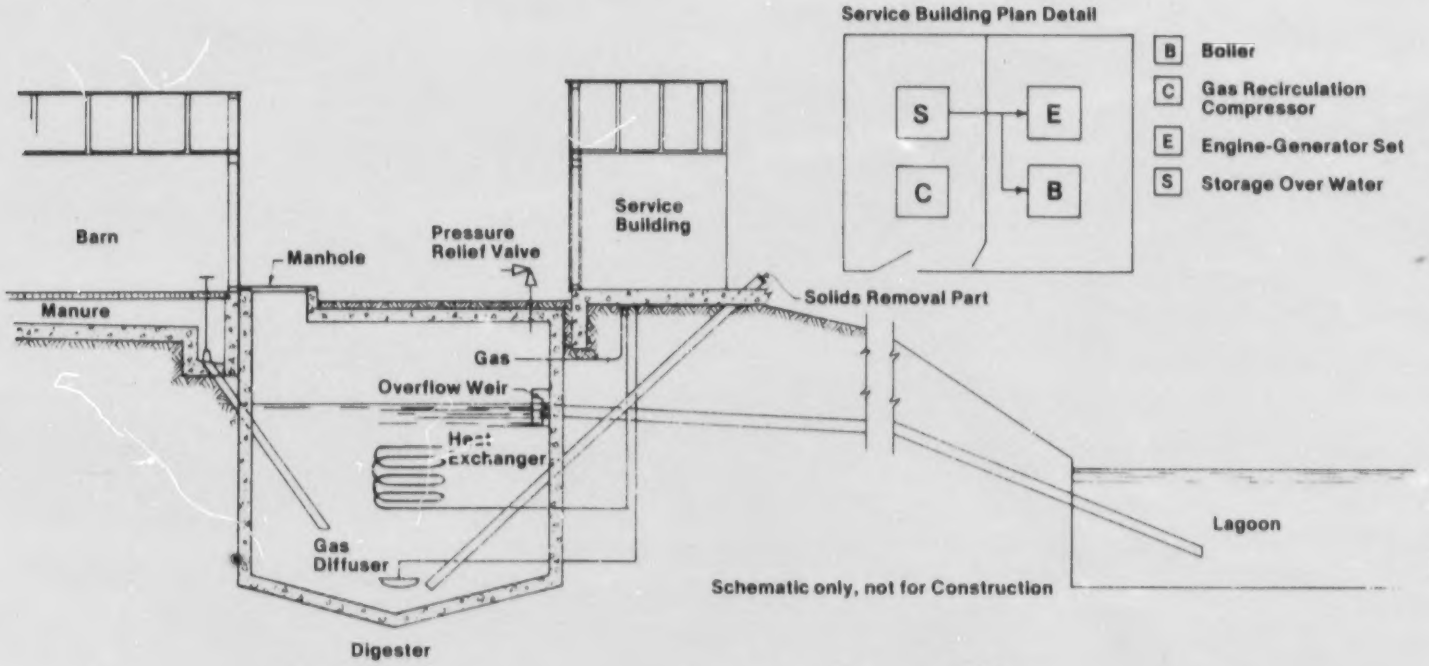
TM1

51

52

SE35

Typical Features of an On-Farm Biogas Plant



ALTERNATIVE ENERGY SOURCES
UNIT II
TEST

Name _____

1. Match the terms on the right to the correct definitions.

   ____ a. A fuel mixture composed of 90% unleaded gasoline and 10% ethanol.

   ____ b. Heat transmitted by sun's rays warms masses of air, water, or other transport mediums.

   ____ c. Collection of electrical energy from the sun.

   ____ d. Energy from the sun is stored through the process of photosynthesis in plants, or other organic material. When the organic material is converted to simpler forms, energy is released.

   1. Thermal Solar Collection
   2. Photovoltaic Energy
   3. Biomass Conversion
   4. Gasohol

2. List the four alternative energy sources.

   a. _____

   b. _____

   c. _____

   d. _____

3. List four reasons why the sun is a useful energy source.

   a. _____

   b. _____

   c. _____

   d. _____

4. True or False statements about Photovoltaic solar cells. Write True in the blank provided if the statement is True, or False in the blank if the statement is False.

   ____ a. Sunlight hits the cell, activating electrons which are collected as cellular energy.

   ____ b. Cells are made primarily of silicon.

   ____ c. Cells will provide some electricity even on cloudy days or under snow cover.

   ____ d. Photovoltaic cells are approximately 3 inches in diameter.

5. Name the five collector parts of a thermal solar collector.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

6. True and False statements about gasohol. Mark True in the blank provided if the statement is True, or False in the blank if the statement is False.

   ____ a. Gasohol has an octane rating above that of unleaded gasoline.

   ____ b. Gasohol causes unusual engine wear.

   ____ c. In World War I and WW II some tanks and planes carried wood stills to produce alcohol when gasoline supplies were short.

   ____ d. Burning gasohol in an internal combustion engine requires some carburetor modification.

7. List seven advantages of using gasohol.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

   f. _____

   g. _____

8. List six disadvantages of using gasohol.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

   f. _____

9. List three historical uses of wind as an energy source.

   a. _____

   b. _____

   c. _____

10. Select from a list the advantages and disadvantages of wind as an energy source. Place an A in front of the answers that are an advantage, and a D in front of those that are a disadvantage.

    ____ a. Non-polluting power source
    ____ b. Renewable energy source
    ____ c. Windmills are inefficient
    ____ d. Wind is an unreliable energy source
    ____ e. Inexpensive energy source.

11. List the seven components of a wind generation system.

    a. _____
    b. _____
    c. _____
    d. _____
    e. _____
    f. _____
    g. _____

12. Describe the two steps of methane production.

    a.
    b.

13. Name the four main features and the nine subfeatures of a methane plant.

    a. _____
    b. _____
        1. _____
        2. _____
        3. _____
        4. _____
        5. _____
    c. _____
        1. _____
        2. _____
        3. _____
        4. _____
    d. _____

ALTERNATIVE ENERGY SOURCES
UNIT II
ANSWERS TO TEST

1. Definitions
   a. 4
   b. 1
   c. 2
   d. 3
2. a. Solar
   b. Gasohol
   c. Wind
   d. Methane
3. a. Natural source
   b. Clean and safe
   c. Inexhaustable energy source
   d. Available year round
4. True/False
   a. False
   b. True
   c. True
   d. False
5. a. Plyboard backing
   b. Absorber surface
   c. Glazing sheet
   d. Dead air sheet
   e. Heating space
6. True/False
   a. True
   b. False
   c. True
   d. False

7. a. Cleaner and lower emissions.

   b. By-products are high in protein and can be fed to livestock.

   c. Reduce the importing of crude oil.

   d. Produced with renewable resources, helps the farmers by providing a new market for his grains.

   e. Average octane rating is 3 points higher than unleaded gasoline.

   f. Gasohol fueled vehicles consume 5% less than those running on unleaded gasoline.

   g. Sufficient amounts of grain and sugar are available in the United States to produce Gasohol without upsetting the food and feed markets.

   h. Gasohol has a higher water tolerance than pure gasoline

   i. Better winter starting, fewer vapor-lock problems during summer

   j. Gasohol can be burned without carburetor modification

   k. Grain used to produce Gasohol need not be the highest quality grain

8. a. Ethanol costs more per gallon than gasoline.

   b. Gasoline has 135,000 BTU, while ethanol has only 85,000 BTU.

   c. Food grains could be used to feed the world's hungry rather than automobiles.

   d. It would require 2.7 times more energy to produce ethanol, than ethanol can deliver to the engine.

   e. The large subsidies required for a gasohol program aren't justified by the small benefits that farmers would receive.

   f. The high energy requirements of mechanized, high-yield farming makes it impractical to depend on agriculture to provide the energy needs of a technological society.

   g. Assuming a nation wide gasohol program, there would be a sharp downward pressure on prices of both distillers dry grain and soybeans

   h. Collection of 75% of agricultural residue and using it for fuel is impractical

   i. For gasohol to be feasible, corn would have to drop off $1 from $3 a bushel and ethylene climb to 15 cents a pound from its present 9 cents before they are competitive

9. a. Used to power sails (ships)

   b. Used to pump water

   c. Used to grind grain into feed and flour.

10. a. A

    b. A

    c. D

    d. D

    e. A

11. a. Propellor

    b. Generator

    c. Tower

    d. Brake

    e. Control panel

    f. Speed control device

    g. Batteries

12. Organic matter is broken down by acid formers, and creates simple organic acids. These simple organic acids are broken down by methane former organisms to produce methane.

13. a. Barn or manure pit

    b. Digestor

       1. Heat Exchanger
       2. Gas Diffusor
       3. Pressure Relief Valve
       4. Solids Removal Pit
       5. Gas

    c. Service Building

       1. Boiler
       2. Gas Recirculation Compressor
       3. Engine
       4. Storage over Water

    d. Lagoon

INTRODUCTION TO SOLAR ENERGY
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to explain why solar energy should be developed as an energy source and describe some characteristics of solar radiation. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of this unit the student should be able to:

1. Match terms associated with solar energy to the correct definitions.
2. List the two main types of solar energy.
3. Name five applications of solar energy.
4. List three advantages of using solar energy.
5. Describe the two disadvantages of using solar energy.
6. Describe three solar radiation principles.
7. List three factors that effect insolation from the sun.
8. Name the two solar energy systems.
9. Identify the components of the active solar system.
10. Discuss how a passive solar system works.

INTRODUCTION TO SOLAR ENERGY
UNIT III
SUGGESTED ACTIVITIES

I. Instructor

A. Provide student with objective sheet.

B. Provide student with information sheet.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheets.

F. Give test.

II. Student

A. Read objective sheet.

B. Study information sheet and take notes.

C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objectives

B. Information sheet

C. Transparency Masters

1. TM 1—Absorption and Reflection

2. TM 2—Diffuse Radiation

3. TM 3—Length of Travel Through the Atmosphere

4. TM 4—Solar Energy System

D. Test

E. Answers to test

II. References

A. "Understanding Solar Energy Systems" Published by Wisconsin Vocational Studies Center, University of Wisconsin-Madison.

B. "Energy Conservation—In the Home—On the Farm" Prepared by Department of Agricultural Education, in cooperation with Ag Ed Section, Bureau of Voc. Ed., Dept. of Ed., Harrisburg, Pennsylvania, with the Pennsylvania State University and Pennsylvania Farm Electrification Council.

C. "Solar Dwelling and Design Concepts" From AIA Research Corporation, Washington, D.C., Government Printing Office, May 1976.

INTRODUCTION TO SOLAR ENERGY
UNIT III
INFORMATION SHEET

I. Terms and definitions

A. B.T.U. (British thermal unit)—Heat required to raise the temperature of one pound of water one degree Fahrenheit.

B. Diffuse radiation—the solar radiation striking the surface of the earth after its direction has been changed by reflection and scattered by particles in the atmosphere—nondirectional rays.

C. Direct radiation—direct or parallel rays from the sun.

D. Energy—the ability to do work.

E. Radiation—any object which is warmer than its surroundings transmits air waves (similar to light waves, but invisible) and, thus, emits energy.

F. Watts—a measure of power in the metric system. (e.g., a 25-watt light bulb)

G. Insolation—amount of radiation which actually strikes the earth.

II. Types of solar energy

A. Photovoltaic

B. Thermal

III. Applications of solar energy

A. Wind power

B. Geothermal energy

C. Photovoltaic cells

D. Dry food materials

E. Heating and cooling buildings

F. Heating domestic and agricultural hot water

G. Heating for other agricultural purposes

1. Grain drying

IV. Advantages of solar energy

A. Solar energy is readily available as are fossil fuels

B. Solar energy is almost inexhaustible

C. Solar energy is nonpolluting

V. Disadvantages of solar energy

A. Sunlight is diffused

B. Sunlight is intermittent
(NOTE: This creates two problems)

INFORMATION SHEET

1. Storage of energy for later use
2. Converting light into energy economically

C. Sunlight is suited for low temperature operation

VI. Solar radiation principles

A. Transmitted to the earth by the sun in the form of wavelengths

B. One-half of the sun's energy is lost due to reflection or absorption (Transparency 1)

C. Insolation (three types)

1. Direct radiation
2. Diffuse radiation
3. Rays deflected from the ground or from object surfaces (Transparency 2)

VII. Insolation available is effected by

A. Purity of the earth's atmosphere

B. Distance the radiation must travel through the atmosphere (Transparency 3)

C. By the angle at which the solar radiation strikes the earth's surface

VIII. Two types of solar energy systems

A. Active systems

B. Passive systems

IX. Components of the active solar system (Transparency 4)

A. Collector

B. Storage

C. Regulation by thermal controls

D. Transport medium

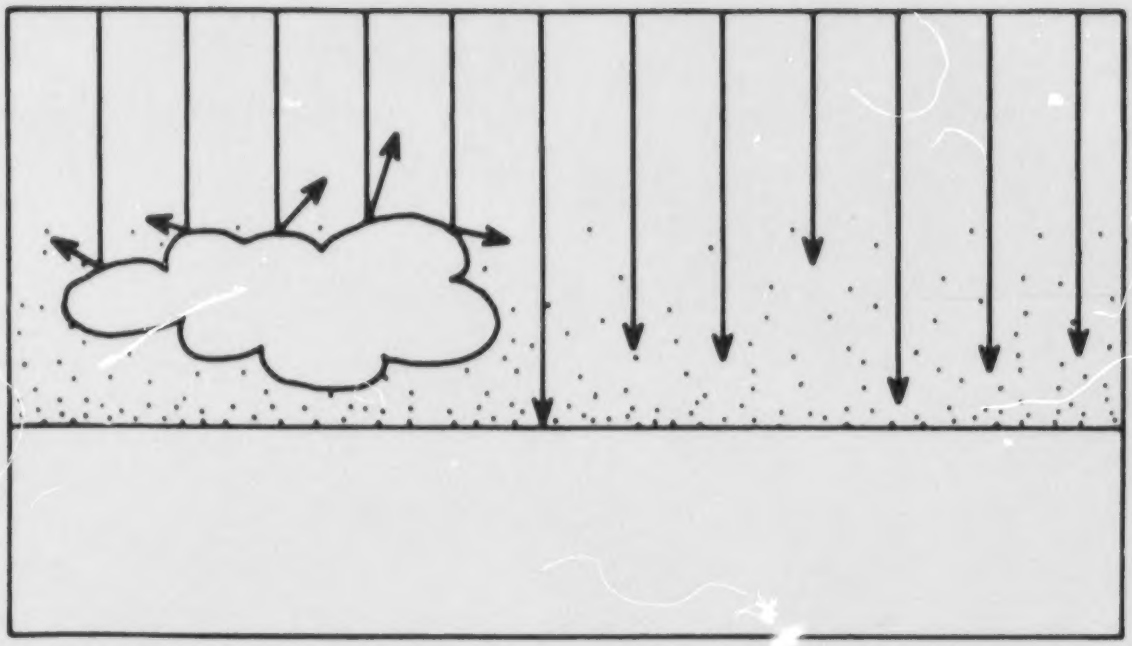
E. Distribution

X. Passive solar systems

A. Heat is transported by natural means

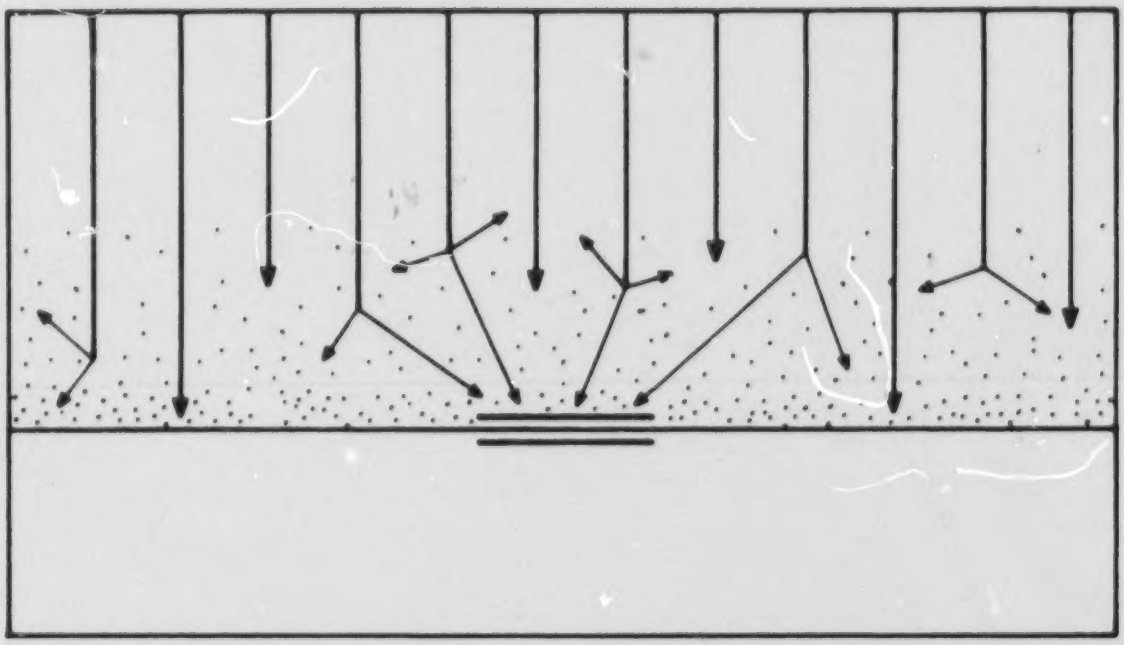
B. Components are typically integrated into the basic design of the dwelling

1. Windows
2. Walls
3. Floors
4. Ceiling



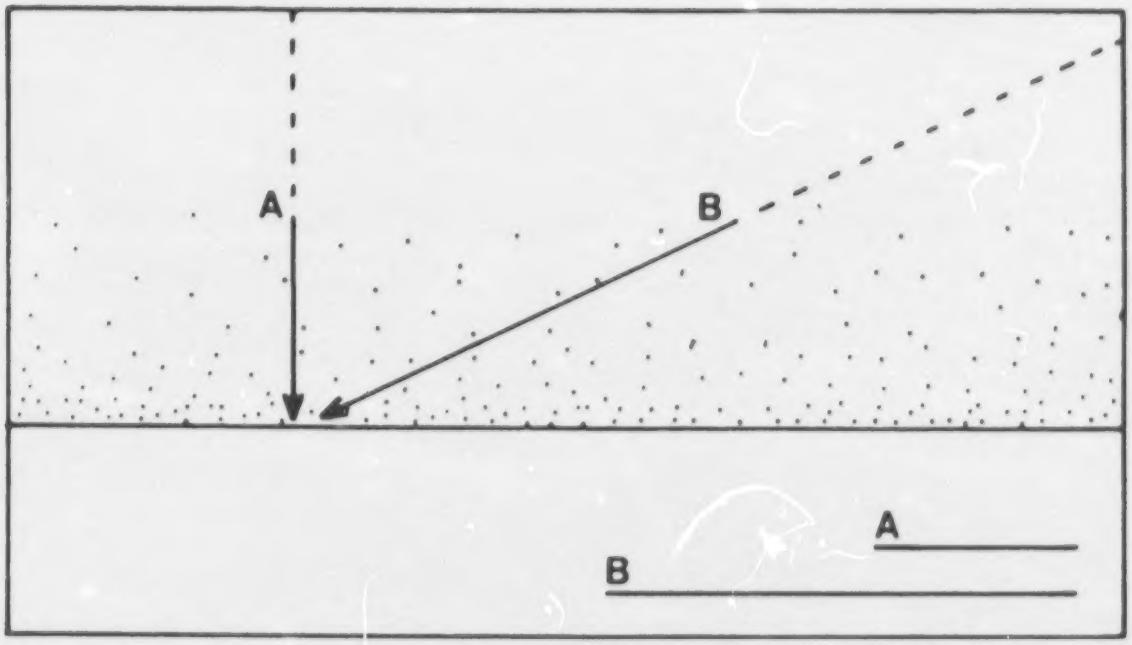
ABSORPTION AND REFLECTION

Nearly half the solar radiation entering the earth's atmosphere is lost through absorption by material in the atmosphere, or by reflection from clouds.



DIFFUSE RADIATION

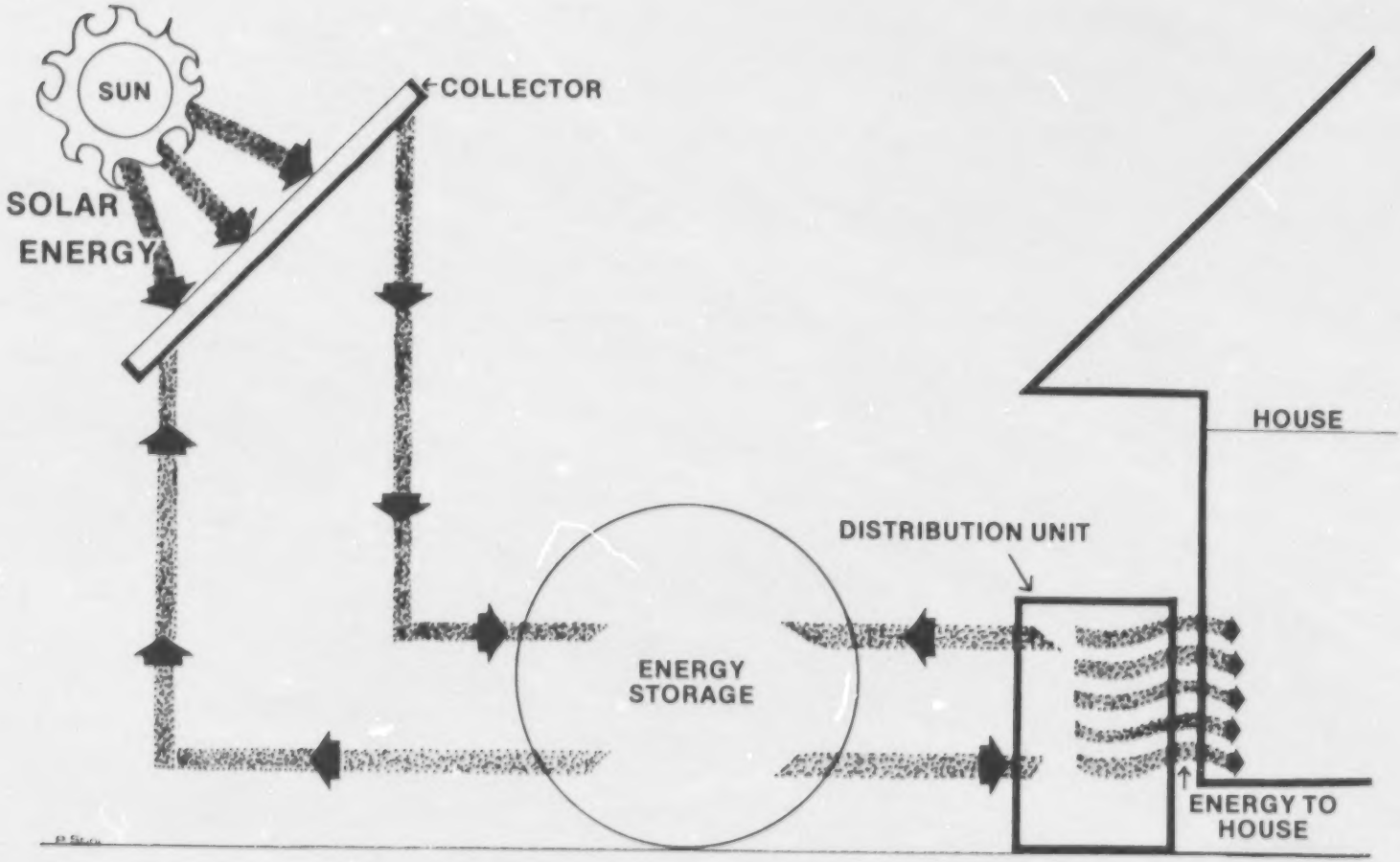
Clouds and particles in the atmosphere not only reflect and absorb solar energy, but scatter it in all directions because of this, solar energy is received from *all parts* of the sky—more so on hazy days than on clear days such radiation is called *diffuse,* as opposed to the normal *direct* radiation.



LENGTH OF TRAVEL THROUGH THE ATMOSPHERE

More solar radiation is lost by absorption at low sun angles because the length of travel through the atmosphere is greatly increased (that is why you can look directly at the sun at sunset.) High altitudes have more solar radiation for the same reason.

Typical Active Solar Energy System



TM 4

SE-79

INTRODUCTION TO SOLAR ENERGY
UNIT VII
TEST

Name _____

1. Match the terms on the right to the correct definitions.

____ a.	A system used to measure heat, British Thermal Unit.	1. Watts
____ b.	The ability to do work.	2. Direct Radiation
____ c.	A measure of power in the Metric system.	3. Energy
____ d.	Any object which is warmer than its surroundings, transmits air waves and thus, emits energy.	4. Radiation
____ e.	Amount of radiation which actually strikes the earth.	5. B.T.U.
____ f.	The solar radiation striking the surface of the earth, its direction has been changed by reflection and scattered by particles in the atmosphere—nondirectional rays.	6. Diffuse Radiation
____ g.	Direct or parallel rays from the sun.	7. Insolation

2. List the two main types of solar energy.

   a. _____

   b. _____

3. Name five applications of solar energy.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

4. List three advantages of using solar energy.

   a. _____

   b. _____

   c. _____

5. Describe two disadvantages of using solar energy.

   a. _____

   b. _____

6. Describe three solar radiation principles.

   a.

   b.

   c.

7. List three factors that effect insolation from the sun.

   a. _____

   b. _____

   c. _____

8. Name the two solar energy systems.

   a. _____

   b. _____

9. Identify the components of the active solar system. (Place an X in the blank next to the correct components)

   ____ a. Transport medium

   ____ b. Distribution

   ____ c. Windows

   ____ d. Thermal Controls

   ____ e. Walls

   ____ f. Storage

   ____ g. Collector

   ____ h. Ceiling

10. Discuss how a passive solar system works.

INTRODUCTION TO SOLAR ENERGY
UNIT III
ANSWERS TO TEST

1. Definitions

   a. 5
   b. 3
   c. 1
   d. 4
   e. 7
   f. 6
   g. 2

2. a) Photovolataic

   b) Thermal

3. A) Wind power
   B) Geothermal energy
   C) Photovolataic cells
   D) Dry food materials
   E) Heating and cooling buildings
   F) Heating domestic and Ag. hot water
   G) Heating for other Ag. purposes
      1. Grain drying, etc.

4. a) Solar energy is readily available throughout the world, not concentrated in a few areas as fossil fuels are.

   b) Solar energy is almost inexhaustable.

   c) Solar energy is nonpolluting. Solar power generation does not produce any by-product which decreases the environment's ability to support life.

5. a) Sunlight is diffuse. It is spread out and must be collected by some means.

   b) Sunlight is intermittent. It is only available during clear days. This creates two problems. One is to develop a way to store energy for later use; the other is converting light into energy economically.

   c) Sunlight is suited for low temperature operation.

6. a) Transmitted to the earth by the sun in the form of wavelengths.

   b) One-half of the sun's energy is lost due to reflection or absorption.

   c) Insolation (3 types): Direct Radiation, Diffuse Radiation, and Rays deflected from the ground or from building surfaces.

7. a) Purity of the earth's atmosphere.

   b) Distance the radiation must travel through the atmosphere.

   c) By the angle at which the solar radiation strikes the earth's surface.

8. a) Active systems

   b) Passive systems

STORAGE AND DISTRIBUTION OF SOLAR ENERGY
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to name and discuss methods of storing and distributing solar energy. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit the student will be able to:

1. Match the terms associated with storage and distribution of solar energy with the correct definition.
2. Select the true statements concerning the storage component.
3. Describe how heat storage is accomplished in a passive system.
4. Describe active heat collection by rock storage.
5. List four advantages of rock heat storage.
6. List three disadvantages of rock heat storage.
7. Describe the components and type of storage container needed for active heat collection by water storage.
8. Select true statements about the advantages of water stored heat.
9. Select true statements about the disadvantages of water stored heat.
10. Describe change-of-state storage.
11. List the two methods and four characteristics of distribution of thermal energy.
12. Select from a list true statements about distribution of heat by natural convection.
13. Identify true statements about distribution of heat from a forced air system.
14. Describe distribution of heat by natural radiation.
15. Describe distribution of heat by forced radiation.

STORAGE AND DISTRIBUTION OF SOLAR ENERGY

SUGGESTED ACTIVITIES

I. Instructor

A. Provide student with objective sheet.

B. Provide student with information sheet.

C. Discuss unit and specific objectives.

D. Discuss information sheets.

E. Discuss and have students perform job sheet.

F. Give test.

II. Student

A. Read objective sheet.

B. Study information sheet and take notes.

C. Complete job sheet.

D. Take test

INSTRUCTIONAL MATERIALS

I. To be included in this unit:

A. Objectives

B. Information sheet

C. Job sheet

D. Test

E. Answers to test

II. References

A. "Understanding Solar Energy Systems" Published by Wisconsin Vocational Studies Center, University of Wisconsin-Madison.

B. "Solar Dwelling and Design Concepts" From AIA Research Corporation, Washington, D.C., Government Printing Office, May 1976.

STORAGE AND DISTRIBUTION OF SOLAR ENERGY
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Natural Convection—the circulatory motion of air caused by thermal gradients without the assistance of mechanical devices.

B. Natural Radiation—the direct emission of energy by a radiation source.

II. The Storage Component

A. Heat is stored by raising the temperatures of materials, such as:

1. rocks
2. water
3. concrete
4. other masonry

B. Storage units must consider several things about selection of materials, these include:

1. cost
2. operation—efficiency and feasibility
3. size

III. Heat storage in passive systems

A. Solar radiation is received through south facing windows or transparent panels

B. How heat is stored:

1. room's air
2. exposed surfaces (walls, floors, furniture)

C. Advantage of passive heat storage is low cost

D. Disadvantage of passive heat storage

1. heat cannot be stored for long periods of time
2. during daytime, space may become overheated making occupants uncomfortable

IV. Active heat collection by rock storage

A. Rock storage is heated by air from the collector

B. Rocks should be 2'' in diameter (minimum)

INFORMATION SHEET

V. Advantages of rock storage

A. Low cost

B. Elaborate heat exchangers are not needed

C. Rocks can store heat above 212°F

D. Low maintenance

E. Air gives up heat quickly to rocks

VI. Disadvantages of rock storage

A. Bulky—requires a large amount of space

B. Larger ductwork, larger fans, and more electricity generally required

VII. Active heat collection by water storage

A. Components

1. working fluid which carries heat from collector to heat exchanger

2. heat exchanger which transfers heat collected by working fluid to storage liquid

3. store heated liquid

B Storage container

1. must be heavily insulated

2. may be made from several materials

a. concrete

b. plastic

c. steel

VIII. Advantages to water stored collection of heat

A. Water has the highest heat capacity per pound of any ordinary material

B. The water is inexpensive

C. Best suited for domestic hot water use

IX. Disadvantages of water stored heat collection

A. Freezing

B. Corrosion of steel tanks and water lines

C. Storage tank is expensive

D. Leakage

INFORMATION SHEET

X. Change-of-state storage

A. Process of changing solid to liquid when heat is stored in this material

B. Great amounts of heat may be stored in a limited amount of space

C. Initial expense may be the limiting factor of this method of storing heat

XI. Methods of distribution of thermal energy

A. Gas flow

1. natural convection

2. forced air

B. Radiation

1. natural radiation

2. forced radiation

XII. Distribution of heat by natural convection

A. Operation

1. hot air from collector or storage enters the room through warm air ducts and rises

2. cooler air begins to fall, passing though cold air returns to be warmed again

B. Requires no mechanical or electrical input

C. Placement of collector and storage is important for successful operation

XIII. Distribution of heat from forced air system

A. Air from either the collector or storage is blown through ducts to the occupied spaces

B. With rock storage, air is simply blown through the rocks into heat ducts

C. With liquid storage, a heat exchanger is required to transfer heat from the liquid to the air

D. Relies on mechanical equipment and electrical energy for distribution

E. With solar produced heat, temperatures are lower and distribution ducts and vents must be larger

XIV. Distribution of heat by natural radiation

A. Radiation entering the space to be heated naturally
Example: Sun warming a greenhouse on a cold day

B. Occurs without the need for any intervening substance such as air or water

C. Radiation can take place without the assistance of mechanical devices

D. Dependent upon differential surface temperature

E. Useful for collector or storage systems, which are directly exposed to the occupied spaces

F. Walls, floors, and ceiling of a dwelling are used to collect and/or store thermal radiation which radiates directly to the rooms cooler surfaces

XV. Distribution of heat by forced radiation

A. Relies on the transfer of heat to air in the space heated by radiation, and convection from circulating hot water liquid flow through tubes

B. Piping for system may be located in the ceiling, floor, or along wall

C. Enlargement of radiating surfaces required over conventional radiation systems, because of lower temperatures collected from solar energy and its storage

JOB SHEET #1—STORAGE OF SOLAR ENERGY

A. Materials Needed

1. A large, well-insulated ice chest (lid off)
2. A clear cover
3. Two thermometers
4. Props for supporting the chest at the latitude angle
5. Five-gallon can painted black, with rubber gasket in screw-top lid
6. Wire
7. Graph paper

B. Procedure

1. Place the chest on the standards with the long axis of the chest pointing east-west and the open top facing south.
2. Using the standards to support the box, tilt the box south at an angle equal to the latitude.
3. Fill the 5-gallon can with water. Be sure the rubber gasket, which can be cut from an inner tube, is flat and in place. Slip the thermometer into a wire holder attached at the back of the 5-gallon can, and place the can in the chest with the thermometer at the top back of the can, i.e., out of the sun. Orient the thermometer so that readings can be taken without uncovering the box.
4. Slip the vinyl cover over the chest—some wire or string or tape should be wrapped around the cover to keep it from blowing off.
5. Hang the air thermometer from a wire at the back of the case, again, out of the sun—in the shadow of the chest.
6. Read the thermometers at 8:00 a.m. and 8:00 p.m. for 7 consecutive days.

C. Explanation

The sun heats the water, but the water loses heat to the surroundings. The water temperature rises on sunny days. The temperature falls during the night or during cloudy weather. On some cloudy days when the clouds are thin and the sky is bright, the temperature may stay even or rise slightly.

The box does not measure the sunshine or the cold very accurately but it does show the difference and this is what is important to a solar-heated house.

The box is not a model of a solar-heated house. The temperature fluctuates much more in the box than in a house.

1. What differences are there in the temperature readings for the two thermometers?
2. Does the temperature inside the box fluctuate more or less than the temperature outside the box?
3. How do the fluctuations in the two temperature readings relate to each other?

STORAGE AND DISTRIBUTION OF SOLAR ENERGY
UNIT IV
TEST

Name _____

1. Match the terms on the right to the correct definitions.

   ____ a. The circulatory motion of air caused by thermal gradients without the assistance of mechanical devices.

   ____ b. The direct emission of energy by a radiation source.

   1. Natural Radiation
   2. Natural Convection

2. Determine whether the following statements are True or False. Write True in the blank if the statement is True, or False in the blank if the statement is False.

   ____ a. Heat cannot be stored by raising the temperature of concrete.

   ____ b. When selecting a storage unit only consider the efficiency and the size of the unit.

   ____ c. Heat can be stored by raising the temperature of substances such as rocks, water, and bricks.

   ____ d. Cost is a factor that influences whether or not you will purchase high quality materials for making a storage system.

3. Describe how heat storage is accomplished in a passive system.

4. Describe active heat collection by rock storage.

5. List four advantages of rock heat storage.

   a. _____

   b. _____

   c. _____

   d. _____

6. List three disadvantages of rock heat storage.

   a. _____

   b. _____

   c. _____

7. Describe the components and type of storage container needed for active heat collection by water storage.

8. True and False statements about the advantages of water stored collection of heat. Write true in the blank provided if the statement is True, or False in the blank if the statement is False.

   ____ a. Water has the lowest heat capacity per pound of any ordinary material.

   ____ b. The water for heat storage is inexpensive.

   ____ c. Water stored collection of heat is best suited for domestic hot water use.

9. True and False statements about the disadvantages of water stored collection of heat. Write True in the blank provided if the statement is True, or False in the blank if the statement is False.

   ____ a. There is no leakage with a water stored collection system.

   ____ b. Water stored collection systems can have freezing problems.

   ____ c. Corrosion of steel tank and water lines do not occur.

   ____ d. Storage tanks for water stored collection systems are expensive.

10. Describe what is meant by a change-of-state storage system

11. List the two methods and four characteristics of distribution of thermal energy.

    a. _____

    1. _____

    2. _____

    b. _____

    1. _____

    2. _____

12. True and False statements about the distribution of heat by natural convection. Write True in the blank provided if the statement is True, or False in the blank if the statement is False.

    ____ a. Hot air from the collector or storage, enters the room through the warm air ducts and rises.

    ____ b. Natural convection requires no mechanical input, but does require electrical input.

    ____ c. Placement of the collector and storage is important for successful operation of a natural convection system

    ____ d. Cool air begins to fall, passing through the warm air ducts so it can be warmed again.

13. True and False statements about distribution of heat from a forced air system. Write True in the blank if the statement is True, or False in the blank if the statement is False.

    ____ a. With rock storage air is simply blown through the rocks into heat ducts.

    ____ b. With liquid storage no mechanical devices are needed to transfer the heat from the liquid to the air.

    ____ c. With solar produced heat, temperatures are lower and therefore distribution vents and ducts don't need to be as large, they can be smaller.

14. Describe distribution of heat by natural radiation.

15. Describe distribution of heat by forced radiation.

STORAGE AND DISTRIBUTION OF SOLAR ENERGY
UNIT IV

ANSWERS TO TEST

1. Definitions:

   a. 2 b. 1

2. True/False

   a. False

   b. False

   c. True

   d. True

3. Direct solar radiation is received primarily through south facing windows or transparent panels. The heat is stored in the room's air or in exposed surfaces such as walls, floors, furniture, etc.

4. The rock storage is heated by air from the collector, and transfered to rocks which should be at least 2 inches in diameter. The rocks will continue to hold the heat.

5. a) Low cost.
   b) Elaborate heat exchangers are not needed.
   c) Rocks can store heat above 212°F.
   d) Requires very little maintenance.
   e) Air gives up heat quickly to rocks.

6. a) Requires a large amount of space.
   b) Need larger ductwork.
   c) Need larger fans
   d) More electricity is required.

7. The components of an active heat collection by water storage unit is the working fluid which carries heat from the collector to the heat exchanger where the heat exchanger transfers the heat collected by the working fluid to the storage liquid, where the heat is stored until it is ready to be used.

   The storage container must be heavily insulated to prevent heat loss, and should be made out of concrete, plastic or steel.

8. True/False

   a. False

   b. True

   c. True

9. True/False

   a. False

   b. True

   c. False

   d. True

10. Change-of-state storage is a process of changing solid to liquid when heat is stored in this material.

11. a) Gas flow

      1. Natural convection

      2. Forced air

    b) Radiation

      1. Natural Radiation

      2. Forced Radiation

12. True/False

    a. True

    b. False

    c. True

    d. False

13. True/False

    a. True

    b. False

    c. False

14. Radiation enters the space to be heated naturally without the need of such intervening substances as air, and no mechanical devices are needed. It depends on differential surface temperatures, and collects thermal radiation which radiates directly to the rooms cooler surfaces.

15. Relies on the transfer of heat to air in the space heated by radiation, and convection from circulating hot water liquid flow through tubes, which gives off heat to its surroundings.

SOLAR COLLECTORS
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the types of solar collectors. Also, they should be able to describe and build a hot air collector. This knowledge will be evidenced by demonstration and scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

Upon completion of this unit the student should be able to:

1. Match terms associated with solar collectors with their correct definition.
2. List three types of flat plate collectors.
3. List two types of concentrating collectors.
4. Identify true statements concerning flat plate collectors.
5. Discuss three characteristics of open water collectors.
6. List two advantages and two disadvantages of open water collectors.
7. Discuss three characteristics of hot liquid collectors.
8. List three advantages and three disadvantages of hot liquid collectors.
9. Demonstrate the ability to construct a vertical wall hot air collector.

SOLAR COLLECTORS
SUGGESTED ACTIVITIES

I. Instructor

A. Provide students with objective sheet.

B. Provide students with information sheet.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information sheets.

F. Discuss and fill out job sheet.

G. Give test.

II. Student

A. Read objective sheet.

B. Study information sheet and take notes.

C. Complete job sheet.

D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objectives

B. Information sheet

C. Transparency Masters

1. TM 1 — Linear Concentrating Collector

2. TM 2 — Circular Concentrating Collector

3. TM 3 — Flat Plate Collector

D. Job sheet

E. Test

F. Answers to test

II. References

A. "Understanding Solar Energy Systems" Published by Wisconsin Vocational Studies Center, University of Wisconsin-Madison.

B. "Solar Dwelling and Design Concepts" From AIA Research Corporation, Washington, D.C., Government Printing Office, May 1976.

C. "Rules of Thumb #3" Construction Suggestions, Solar Vertical Wall Collector, Small Farm Energy Project, Center For Rural Affairs, Hartington, NE.

SOLAR COLLECTORS
UNIT V
INFORMATION SHEET

I. Terms and definitions

A. Collector—a device for receiving solar radiation and converting it to heat.

B. Concentrating collector—collectors which use reflectors to focus solar radiation on a small area.

C. Flat plate collector—collectors so named because of the large surface area exposed to the sun.

D. Heat transfer medium—a liquid or gas which absorbs heat efficiently and moves the heat away from the collector to storage or to point of use.

II. Types of flat plate collector

A. Open water collector

B. Hot liquid collector

C. Hot air collector

III. Types of concentrating collectors (Transparency 1 and 2)

A. Linear concentrating collector

B. Circular concentrating collector

(Note: On the basis of simplicity, the rest of this unit will be in disucussion of the flat plate collector, its three types and construction of the hot air collector.)

IV. Flat plate collector facts

A. Absorbs both diffuse and direct radiation (Transparency 3)

B. Works best when collector is perpendicular to the sun

1. The tilt need not be exact

V. Open water collectors

A. Water is trickled over grooves in the black absorber surface

B. Water picks up heat as it travels down the surface and is collected and piped to its destination

C. Glass cover is used over collector to prevent evaporation losses

VI. Advantages and disadvantages of open water collectors

A. Advantages

1. Water is a good transport fluid and is cheap

INFORMATION SHEET

2. Collector can be constructed on building site

B. Disadvantages

1. Freezing of water occurs in very cold climates

2. Water condenses on inside surface of glass cover, decreasing efficiency

VII. Hot liquid collector

A. Liquid is put through pipes connected to collector plate

B. Heat transfer from plate to water inside pipes is by conduction

C. Heated liquid is transported to its desired use

VIII. Advantages and disadvantages of hot liquid collectors

A. Advantages

1. Efficient in collecting and transporting heat

2. Liquids absorb heat more readily

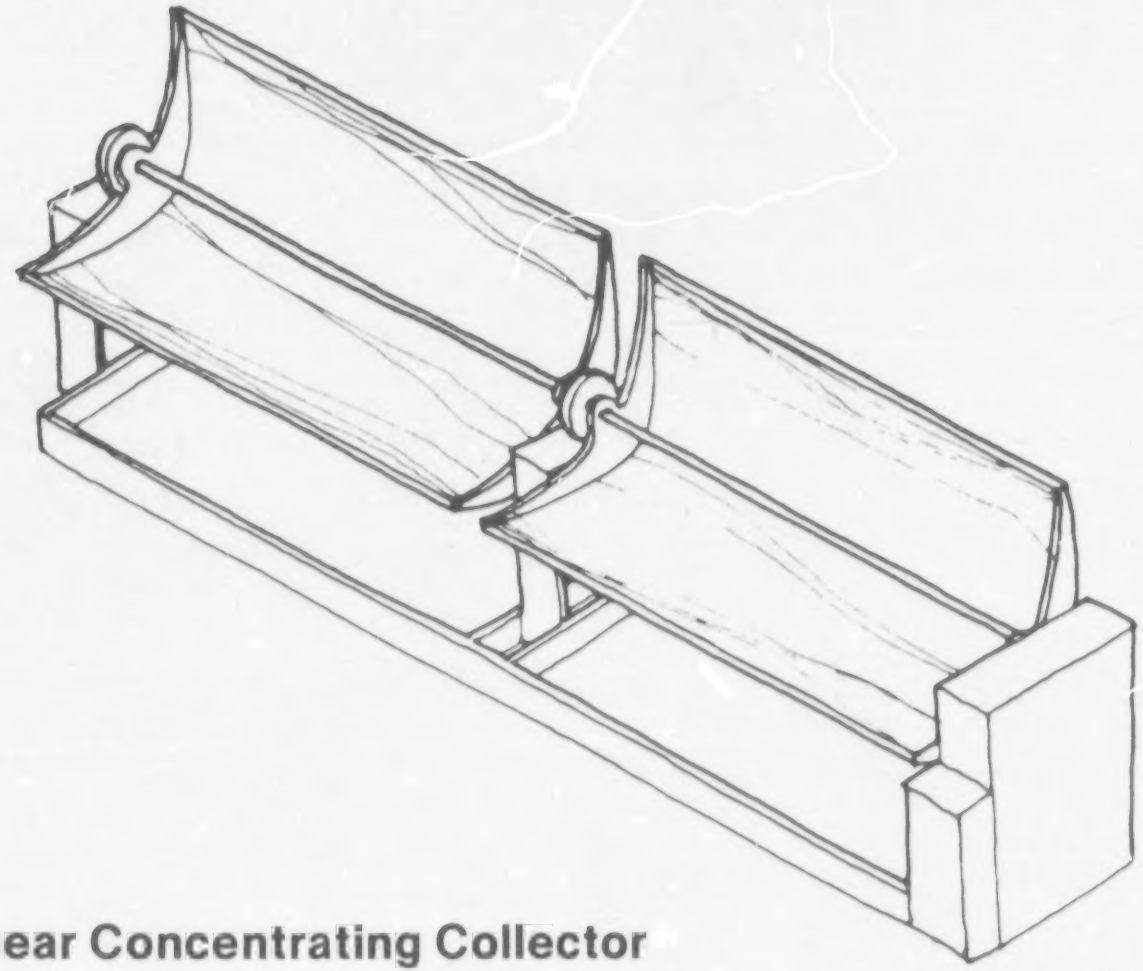
3. Requires smaller space for piping

B. Disadvantages

1. If water is used for heat transfer, freezing is dangerous and repairs are very costly

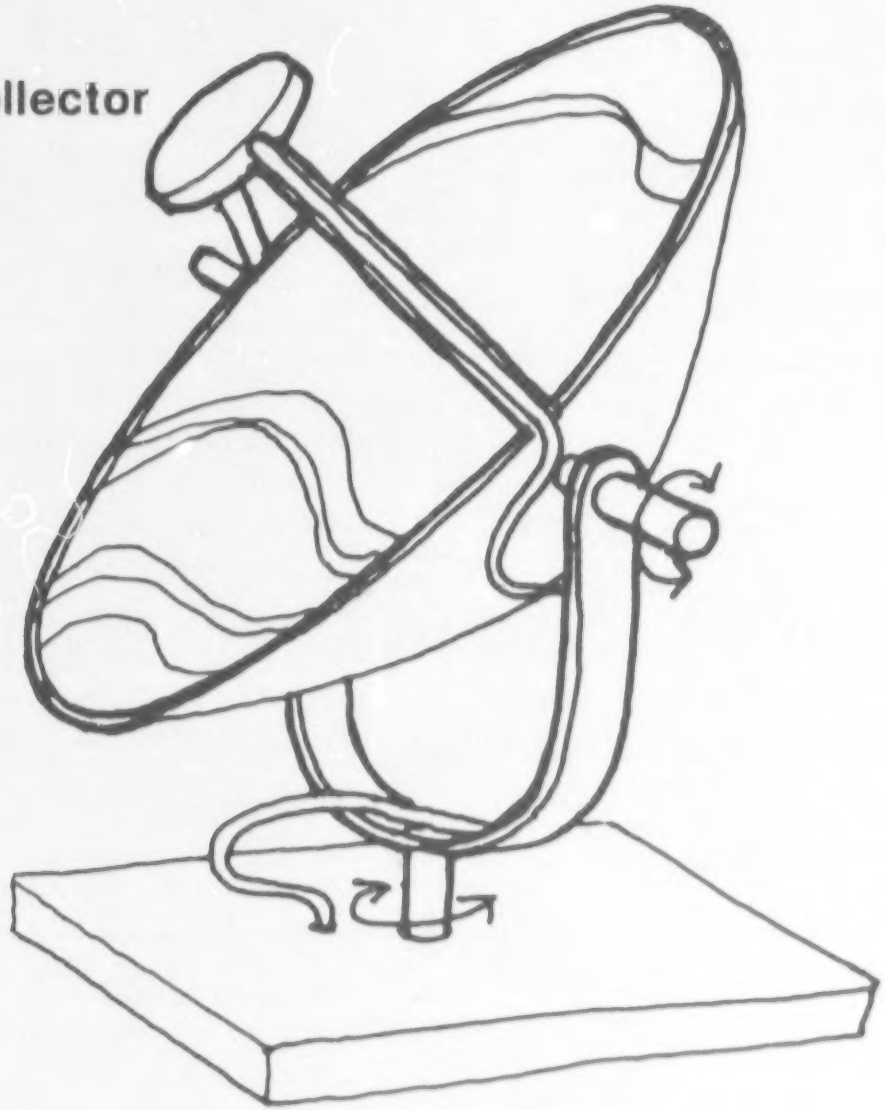
2. Controls to avoid freezing are costly

3. If antifreeze is used, corrosion can decrease collectors efficiency



Linear Concentrating Collector

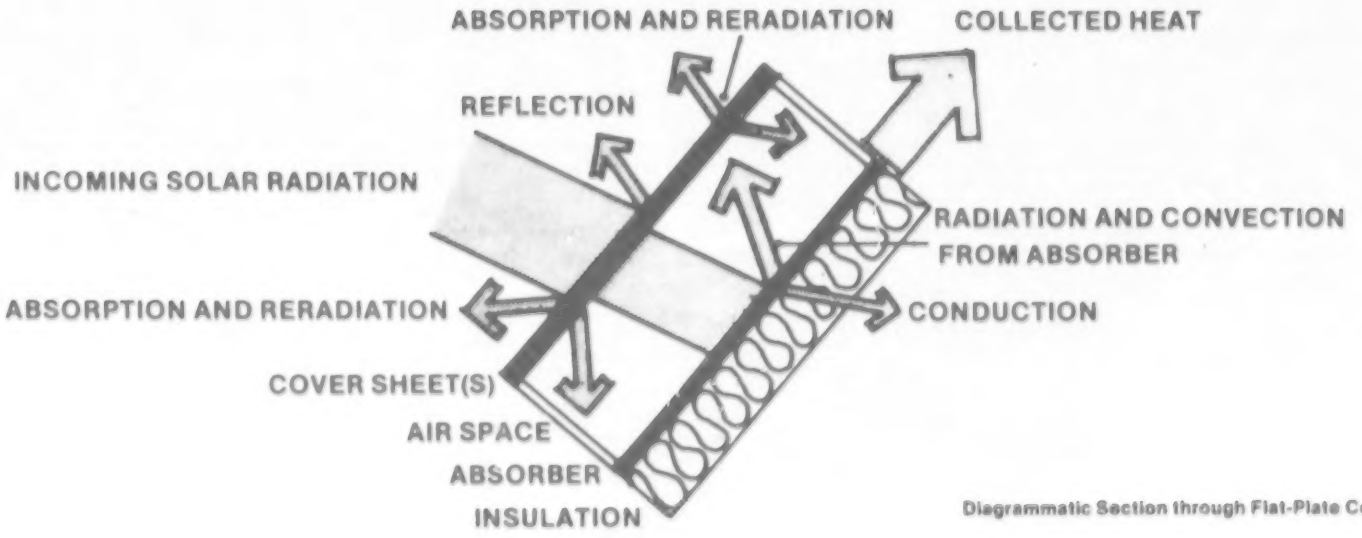
Circular Concentrating Collector



TM 2

SE-109

Flat Plate Collector



Diagrammatic Section through Flat-Plate Collector

TM 3

SE-111

SOLAR COLLECTORS

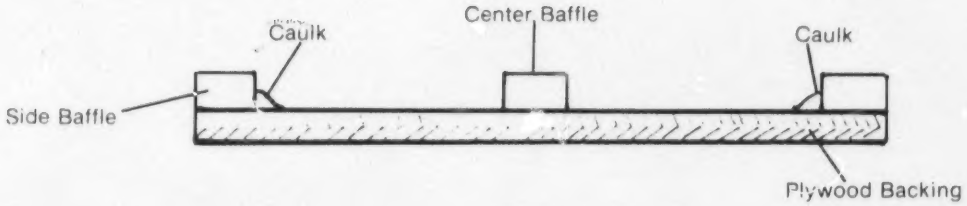
JOB SHEET NO. 1: CONSTRUCTION OF THE VERTICAL WALL HOT AIR COLLECTOR

NOTE: With permission of the Small Farm Energy Project sponsored by the Center For Rural Affairs, P.O. Box 736, Hartington, NE 68739.

Every collector has a different design, depending on where it is to be used and on the materials available. A good imagination and common sense will generate a good design and construction method.

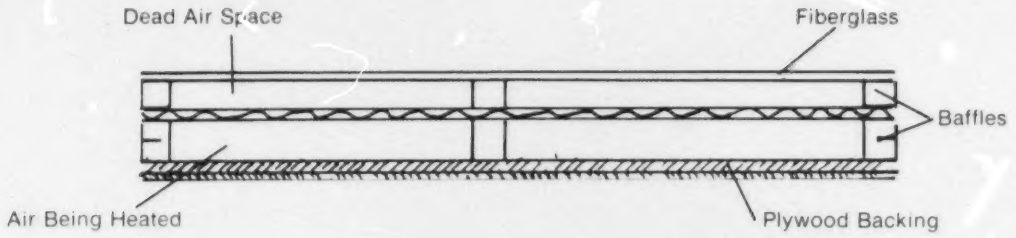
1. Lay out plywood backing and cut to size. Keep the joint of the plywood at the center of the collector in order that the center baffle will seal and tie the plywood. The plywood is not used on the back of large systems.

2. Nail and glue side baffles and center baffles of 2 x 2 to plywood. On large collectors baffles are nailed directly over wall studs with ring shank nails. (Note that the baffles are best located so as to conform to the 4' width of flat fiberglass, when used.)



3. Caulk all exterior corners with latex or equivalent caulk. Aluminum press plate can be used on the plywood or siding to reflect heat, but it is not necessary. Cut holes in the plywood. On larger collectors, holes are cut into the rim joints of the building or the wall for the inlet and outlet of the collector. For straight horizontal runs, holes can be cut in the siding using the stud spaces as the ducts at the ends of the collector.

4. Mount wire mesh or plaster lathe in the air way of the warm half of the collector in 2' sections or less. Slope to force air toward the metal. This increases heat transfer efficiency by supplying more area in the air flow. When cutting mesh, leave tabs on one end for tacking to the top of baffles.



5. Place large screws or nails in the plywood or siding at air turns where no baffle exists, to offer support to the metal plate. Drill holes at "dead air corners".

6. Clean and etch corrugated galvanized metal, if used, with solvent, soap or detergent and water, and vinegar of muriatic acid, in that order. Do not stack galvanized metal in a tight pile if wet, as oxides will build up on the metal. If baked enamel metal is used, buff with steel wool or sand paper, and paint.

7. Paint galvanized metal with primer. No primer is required on baked enamel and not necessary on the back side of corrugated galvanized. Paint back side first; metal can then be mounted and then the front side is painted. Use flat black paint of over 250 degree F heat tolerance.

8. Mount corrugated nail to baffles with foam seals under corrugated ends, and with foam seals over air dividers. When using metal with large corrugations, obtain neopreme strips specially made for the larger corrugations. Corrugated metal is mounted with corrugations perpendicular to most of the air flow for greater turbulence and efficiency. Nail metal in valleys of corrugations.

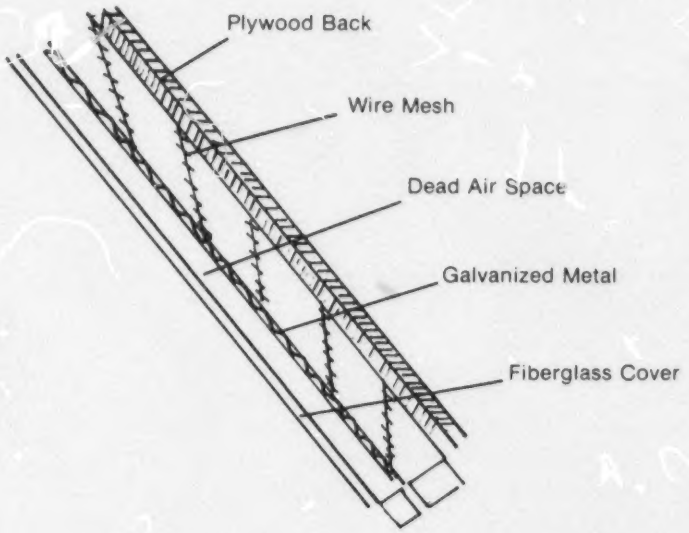
9. Caulk and pop rivot corrugated metal at seams. Use "water seal" caulk which is best for painting. Mount the top and bottom 2 x 4 frame members.

10. Clean, etch and paint the front side as needed if not yet completed. Touch up the plate if already painted. Use primer unless baked enamel is being used.

11. Foam or neopreme seal strips are now added around the perimeter of the metal as needed to seal corrugations, before battens are added over the top. Caulk top edges at perimeter of the collector plate.

12. Place battens of 1 x 2 over corrugated metal and nail to baffles. Battens are used to support the fiberglass. Paint battens black or white. White reflects onto metal, but black is easier to apply. (Note that battens are located at splice points of fiberglass, usually on 4' centers, in case of the flat fiberglass.)

CONSTRUCTION OF THE VERTICAL WALL HOT AIR COLLECTOR (Continued)



13. Install fiberglass. Screws will allow easy removal; use with neopreme washers to seal where wood strips are not used. Tack first the sides and splices with small nails to locate sheet. Use wood lattice at these points with screws. If flat fiberglass is used, install when warm for best tension and tightness. Use only butted seams, no overlap. Corrugated fiberglass gives better rigidity and sometimes better appearance, but requires extra corrugated sealer strips around perimeter. Use silicone clear caulk beneath fiberglass at seams, edges, top, and bottom.

14. Mount ¼" lattice over splices of fat fiberglass with screws. Mount to sides and top of collector over fiberglass. (Note that lattices can be pre-painted before mounting, and may be simpler. No lattice is used on bottom.)

15. Caulk the perimeter of the collector for good seal over fiberglass and metal. Then mount 1 x 4 trim boards to the perimeter of the collector. Corners can be mitered, if desired.

16. Paint trim. Add flashing to top and bottom as needed, to weatherize.

17. Install fan, controls and ducting wire.

18. If desired, ½" holes can be drilled into the top and bottom corners of the collector into the dead air space above the collector plate, for summer ventilation. Add pipe screens. Plug with lag bolts for winter. This may lengthen life of collector, protecting from excess heat. However, the sun is high in the summer and does strike the vertical wall collector, and therefore it remains cool.

SOLAR COLLECTORS
UNIT V
TEST

Name ____ _____

1. Match the terms on the right to the correct definitions.

____ a. A device for receiving solar radiation and converting it to heat.

____ b. Collectors so named because of the large surface area exposed to the sun.

____ c. Collectors which use reflectors to focus solar radiation on a small area.

____ d. A liquid or gas which absorbs heat efficiently and moves the heat away from the collector to storage or to point of use.

1. Concentrating Collector
2. Heat Transfer Medium
3. Collector
4. Flat plate Collector

2. List the three types of flat plate collectors.

a. _____

b. _____

c. _____

3. List the two types of concentrating collectors.

a. _____

b. _____

4. True and False statements about flat plate collectors. Write True in the blank provided if the statement is true, or False if false.

____ a. Flat plate collectors absorb only direct radiation.

____ b. Flat plate collectors work best when the collector is perpendicular to the sun.

____ c. The tilt of the flat plate collector needs to be exact.

5. Discuss three characteristics of open water collectors.

a.

b.

c.

6. List 2 advantages and 2 disadvantages of open water collectors.

   Advantages

   a. _____

   b. _____

   Disadvantages

   a. _____

   b. _____

7. Discuss three characteristics of hot liquid collectors.

   a.

   b.

   c.

8. List 3 advantages and 3 disadvantages of hot liquid collectors.

   Advantages

   a. _____

   b. _____

   c. _____

   Disadvantages

   a. _____

   b. _____

   c. _____

SOLAR COLLECTORS
UNIT V
ANSWERS TO TEST

1. Definitions

   a. 3

   b. 4

   c. 1

   d. 2

2. a. Open water collectors

   b. Hot liquid collectors

   c. Hot air collectors

3. a. Linear concentrating collector

   b. Circular concentrating collector

4. True/False

   a. False

   b. True

   c. False

5. a. Water is trickled over grooves in the black absorber surface.

   b. Water picks up heat as it travels down the surface and is collected and piped to its destination.

   c. Glass cover is used over the collector to prevent evaporation losses.

6. Advantages

   a. Water is a good transport fluid and is cheap.

   b. Collector can be constructed on building site.

   Disadvantages

   a. Freezing of water could occur in very cold climates.

   b. Water can condense on inside surface of glass cover, and thus decrease efficiency.

7. a. Liquid is put through pipes connected to collector plate.

   b. Heat transfer from plate to water inside pipes is by conduction.

   c. Heated liquid is transported to its desired use.

8. Advantages

   a. Efficient in collecting and transporting heat.

   b. Liquid absorbs heat more readily.

   c. Requires smaller space for piping.

   Disadvantages

   a. If water is used for heat transfer, freezing is dangerous and repairs are very costly.

   b. Controls to avoid freezing are costly .

   c. If antifreeze is used, corrosion can decrease collectors efficiency.